
Selected Abstracts from the 2012 Howard H. Steel Conference

Evidence-Based Pediatric Spinal Cord Injury Medicine

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“We Have Snake Eyes”: Identifying the Dual Diagnoses of Ischemic Spinal Cord Injury and Traumatic Brain Injury in the Acute Pediatric Rehabilitation Setting

Suzanne Prestwich

Summary: *This case report poster describes the identification and management of a pediatric patient with acute traumatic brain injury who was ultimately found to have undiagnosed traumatic spinal cord ischemia from vertebral artery dissection and highlights the need for awareness of the dual diagnoses of spinal cord injury and traumatic brain injury.* **Case presentation:** This poster describes the clinical course of an 18-year-old male patient who presented for inpatient rehabilitation from a trauma center with the primary diagnosis of severe traumatic brain injury (TBI). Initial MRI of his spine showed no acute spinal cord injury (SCI). During the course of his inpatient rehabilitation admission, he presented with classic symptoms of SCI. He had difficulty voiding spontaneously, constipation, muscular wasting, and low serum testosterone. His exam showed decreased spontaneous movement of all extremities without motor recovery that would be expected in a TBI patient. This raised concerns for possible undiagnosed SCI. Consultations from the pediatric neurology and pediatric SCI teams recommended evaluation of the entire neuroaxis with MRI. Follow-up MRI of the spine showed

increased T2 signal in the anterior horns in the cervical spinal cord from C3 to C6 reflective of traumatic ischemic injury. Commonly referred to as “snake eyes,” this sign is pathognomonic for ischemic myelopathy. MRI imaging of this finding will be provided. Vertebral artery angiography was performed to evaluate the need for additional therapy or intervention. Angiography revealed findings suggestive of prior but healed vertebral artery dissection, with evidence of collateral spinal cord arterial supply. Angiography imaging of this finding will be provided. The results of the angiography did not support the need for further anticoagulation or intervention, as the patient received anticoagulation in the trauma center for bilateral jugular and left gastrocnemius deep vein thrombi (DVTs). **Conclusion:** This case is an excellent example of the need for awareness of SCI presenting in a TBI patient, despite normal initial MRI imaging. The patient presented with classic signs of SCI including tetraplegia, muscular wasting, neurogenic bowels, neurogenic bladder, and low testosterone. Given the finding on MRI of increased T2 signal in the anterior horns in the cervical spinal cord C3-C6 or “snake eyes,” consistent with ischemic myelopathy, further study was warranted to assess the extent of injury and to determine if further treatment was needed. Treatment of DVTs in the trauma center likely also treated the previously undiagnosed vertebral artery dissection.

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An Update on Pediatric Diaphragm Pacing: What We Learned and How Diaphragm Pacing Is an Excellent Option in Pediatric Spinal Cord Injured Patients

Mary Jo Elmo

Summary: *Diaphragm pacing is a viable breathing option in pediatric SCI. This is an update of pediatric diaphragm pacing at one institution highlighting the differences between children and adults.* **Background:** Diaphragm pacing (DP) has successfully replaced or decreased tracheostomy mechanical ventilation (TMV) in adult SCI. The incidence of cervical cord injuries is disproportionately high in young children. The success of DP in the pediatric patient has been previously described. This report will summarize all pediatric patients implanted at one institution highlighting the differences in surgical implantation and diaphragm condition among the age groups. **Methods:** Retrospective review of all implanted pediatric DP patients. **Results:** A total of 11 patients between ages of 27 months and 17 years were implanted between January 2009 and May 2012. Additionally at operative exploration, 2 patients unexpectedly had denervated diaphragms and were not implanted. Four patients were between 2-3 years old, 2 were 5 years old, 4 patients were between 9-10 years, and 1 was 17 years old. The average time spent on TMV was 31.65 months with a range of 11 days to 91 months. Over 50% (6) of patients achieved full time pacing. Three patients are off the ventilator for 12-16 hours daily while the others are still in the conditioning phase. One patient, from the possible neuroplasticity effects of functional electrical stimulation, regained full volitional breathing with easy removal of the wires. No patients had perioperative or postoperative complications. To date, there are no long-term complications. The 2 patients implanted early post injury went directly to full time pacing. Scoliosis and use of a hard shell back brace can affect pacing. Children ages 4-5 and those on TMV greater than 5 years have the most anxiety with pacing. Utilizing the pacer simultaneously with TMV can lead to severe hypocapnia. As little as 15-20 minutes of pacing time daily can significantly

improve lung compliance affecting tidal volumes when using pressure control mode. Parents report improvement in freedom, independence, mobility, and activity with pacing. **Conclusions:** Early diaphragm pacing is the optimal utilization and may help with functional recovery. In the 2- to 3-year-olds, the major obstacle to pacing is habituating to the change in sensation. In the 5- to 10-year-olds, the major obstacle to pacing is fear. Early implantation decreases conditioning times. Pacing improves quality of life.

1073

Combined Umbilical Stoma for Mitrofanoff and Malone Procedure for Enhanced Cosmesis

Gregory Dean

Summary: *This abstract demonstrates that a double-barreled umbilical stoma can be created during a combined antegrade continence enema (ACE)/Mitrofanoff procedure producing a cosmetically superior outcome.* **Purpose:** The application of the Mitrofanoff procedure as well as the development of the Malone procedure have advanced the treatment of children with neurogenic bladder and bowel dysfunction. Recent application of a split appendix approach in select patients has yielded excellent results with the potential for decreased operative times and enhanced patient outcomes. We have employed this technique and describe a novel adaptation permitting the creation of a common umbilical location for both stomas. **Methods:** A retrospective chart analysis identified 25 patients in our clinic who had undergone combined Mitrofanoff appendicovesicostomy and Malone reconstruction since 2002. Of that number, 5 patients underwent a split appendix technique. Four of those patients underwent creation of a common umbilical location. Their ages at the time of surgery ranged from 4 years to 14 years (mean 8 years) with a mean follow-up of 20 months. Three of the 4 have myelomeningocele and the fourth patient has a history of a spinal cord injury. None of the patients require bladder

augmentation. During the procedure, the cecum is mobilized and the appendix split. Two U-shaped flaps are inscribed within the umbilical floor and then used to anastomose to separate split appendix stomas. **Results:** Since 2007, 4 patients underwent creation of a common umbilical stoma. All stomas are actively used, and none have required revision. No patients experienced increased urinary tract infections postoperatively. Families report high satisfaction with the cosmetic outcome. **Conclusion:** A common umbilical location for the split appendix Mitrofanoff and Malone is simple to construct and yields outstanding cosmetic and functional outcomes. This novel adaption should be considered in all patients undergoing this combined procedure.

1035

Prevalence of Malnutrition in Pediatric Patients with Spinal Cord Injury

Allison Graham

Summary: National guidelines have set recommended standards for nutrition screening in paediatric patients since 2003, but data on the prevalence of malnutrition (both over and under) in children with spinal cord injury remain limited with the possibility of malnourished children going undetected. This research will focus on validating the existing nutrition screen. **Rationale:** National guidelines have set recommended standards for nutrition screening in paediatric patients¹ since 2003, but data on the prevalence of malnutrition in children with spinal cord injury (SCI) remain limited. **Methods:** The present study aimed to establish the risk of undernutrition defined from published criteria including (1) Screening Tool for Assessment of Malnutrition in Paediatrics² (STAMP) score = 2; (2) Paediatric Yorkhill Malnutrition Screening³ (PYMS) score = 1; (3) weight for height <90%⁴; and (4) full dietetic assessment. Overnutrition was defined from body mass index (BMI) centile with =91st as overweight and =98th as obese. **Results:** Sixty-two children (mean age: 11.4 years; SD 4.9; median: 13 years; interquartile range: 7.8–15.6; 39.4% female) with

SCI (46.5% tetraplegia; 53.4% complete SCI) were assessed. The present study found that the prevalence of overnutrition was high (BMI centile =91st: 60%; BMI centile =98th: 26.7%). The prevalence of undernutrition varied depending on the definition used (STAMP, 42.1%; PYMS, 45.1%; Waterlow score, 17.6%; dietitian assessment, 29.4%). Only 60% at-risk patients were referred for further nutrition assessment. Comorbidities included previous intensive care unit stay (55.6% vs 20.8%; $P < .05$); mechanical ventilation (58.3% vs 18.2%; $P < .01$), and need of artificial nutrition support (75% vs 12.8%; $P < .01$) and these may be additional risk factors of undernutrition. **Conclusion:** Both over- and undernutrition are common in children with SCI. Malnourished children appear to be going undetected. Further research will focus on validating the existing nutrition screening tools and how these compare to other published methods.

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1044

Self-Management: Concepts, Evidence and Considerations for Use with Adolescents with SCID

Michelle Meade

Summary: The philosophy, evidence-base, and use of self-management with adolescents with SCID will be presented and audience participation and discussion encouraged. **Data:** Self-management is an approach and philosophy which has at its core the self-determination and empowerment of the individual with the disability or chronic condition.

The term “self-management” generally is used to refer to the ability of individuals with a chronic condition to manage their health and its physical and psychosocial consequences. Basic components of self-management including self-monitoring, problem-solving, and communication strategies. This presentation will provide background about the evidence-base for self-management, including developmental considerations. Information about Health Mechanics, a self-management program developed by Michelle Meade (one of the presenters), will be presented and initial data provided from a pilot study assessing its effectiveness in reducing secondary conditions among adults with chronic SCI. Audience members will be asked to participate in a discussion of its translation for use with adolescents with SCID.

1033

Validation of the Screening Tool for the Assessment of Malnutrition (STAMP) in Patients with Spinal Cord Injuries

Samford Wong

Summary: *Validation of a nutrition screening tool in a paediatric SCI population.* **Introduction:** Reported incidence of childhood malnutrition varies from 15% to 30%^{1,2} in hospitals; this may be higher in neuro-disabilities patients such as spinal cord injuries (SCIs). A number of paediatric nutrition screening tools (PNST) have been developed,^{1,2} but their use in the SCI population requires further investigation. **Objectives:** The aims of the study were to validate the Screening Tool for the Assessment of Malnutrition (STAMP)¹ in patients with SCI. **Methods:** On admission, children were screened by STAMP by nursing staff. The validity of STAMP was assessed by (i) comparison with dietetic assessment (criterion validity); (ii) comparison with another generic PNST – Paediatric Yorkhill Malnutrition Score² (PYMS) (concurrent validity); and (iii) completion of an additional PNST form completed by the research dietitian to assess inter- and intrarater reliability. The agreement was assessed using Cohen’s kappa statistics.³ **Results:**

Using STAMP, 51 children were able to be screened. The prevalence of undernutrition risk range was 42.1%. STAMP had a moderate agreement with dietitian assessment (κ : 0.578; 95% CI, 0.304-0.851) and a fair agreement with PYMS (κ : 0.314; 95% CI, 0.08-0.552). The STAMP had a substantial reliability (interrater reliability: κ : 0.752; 95% CI, 0.568-0.935; intrarater reliability: κ : 0.635; 95% CI, 0.392-0.878). When compared with dietetic assessment, STAMP had a lower sensitivity (70.6% vs 76.4%), lower specificity (87.5% vs 93.7%), and lower agreement to PYMS (κ : 0.58 vs 0.69). **Conclusions:** Although the diagnostic accuracy is lower when compared with other generic PNST, STAMP is still an acceptable (valid and reliable) tool to identify SCI children at risk of undernutrition. Further investigation is warranted to test its predictive validity.

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1043

Validity of the Anorectal Examination as the Sole Indicator of Spinal Cord Injury Severity: Preliminary Results

Laura Krisa

Summary: *To validate the use of functional magnetic resonance imagining for the purpose*

of classifying the severity of spinal cord injury in children. **Purpose:** To validate the use of functional magnetic resonance imaging (fMRI) for the purpose of classifying the severity of spinal cord injury (SCI) in children. **Methods:** Seven male and 2 female patients, average age 14.3 years, underwent one complete International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) examination (motor, sensory, and anorectal exam) by 1 of 2 trained therapists. Subjects also underwent the anorectal portion of this exam while fMRI data were collected using a 3.0 Tesla Siemens Verio Scanner. Cortical areas of activation were analyzed to study possible differences of cortical involvement between complete (AIS A) and incomplete (AIS B, C, and D) SCI subjects. Anxiety/anticipation of the test was also assessed. **Results:** Preliminary results on first level analysis found bilateral cortical activation ($P = .001$) of Brodmann area 6 (premotor) in addition to unilateral activation in prefrontal and premotor areas during the anticipation of deep anal pressure (DAP) being applied to the rectal wall among all subjects. Bilateral activation occurred in Brodmann areas 6 and 40 (part of Wernicke's area) during DAP. In contrast, subjects had less prefrontal cortical activation during the anticipation of being asked to contract their external anal sphincter, while areas 8 (frontal eye field), 6, and 19 (visual cortex) were found to be activated during external anal sphincter contraction. **Conclusion:** Preliminary findings indicate that fMRI is a useful tool in evaluating the validity of the anorectal examination to determine SCI severity. Assessing which cortical regions are activated during the testing procedure is an indication of which pathways are transmitting information to the brain. In addition to the information this technique can provide about the cortical regions involved in the test of SCI severity, we are also able to examine the anxiety/anticipation this test causes in youth and adolescents.

Longitudinal Monitoring of Outcomes

1072

Functional and Musculoskeletal Outcomes from Age 5 to Adolescence Following Walking Recovery in a Child with Severe, Incomplete Spinal Cord Injury

Shelley Trimble

Summary: *The purpose of this report is to describe the child's walking function, musculoskeletal development, and health post locomotor training and walking recovery from age 5 to adolescence and to identify any needs requiring additional intervention or referral.* **Background & Purpose:** We previously reported on a child injured at 3.5 years of age with a severe, cervical incomplete spinal cord injury (SCI) and who was nonambulatory after injury. At 16 months post injury, the child participated in 76 sessions of an activity-based therapy – locomotor training (LT). During LT he recovered walking independence with a reverse rolling walker. Follow-up during this child's critical years of growth and development is necessary to describe long-term consequences of walking recovery in pediatric SCI and to identify subsequent intervention needs. As nearly 100% of children with SCI prior to age 5 develop scoliosis and 87% with SCI prior to age 10 develop hip dysplasia, we were especially interested in the child's musculoskeletal health. In addition, we asked what impact increasing age, growth, and complexity of social and educational demands have on the child's walking capacity and function in the home, school, and community. The purpose of this report is to describe the child's walking function, musculoskeletal development, and health post LT and walking recovery from age 5 to adolescence and to identify any needs requiring additional intervention or referral. **Case Description:** The child was re-evaluated at 1, 2, 5, and 7 years post initial LT and walking recovery. We examined the following domains with these specific measures: (1) sensorimotor function, (2) gross motor function (GMFM; Pediatric Balance Scale, Neuromuscular Recovery Scale, other locomotor tasks), (3) walking (speed, endurance,

step activity), (4) musculoskeletal health (lower extremity muscle MRI; height, weight, spine, and hips x-rays; ROM/flexibility, alignment), and (5) quality of life (Peds QL). **Outcomes:** The child's Lower Extremity Motor Score remained unchanged at 4/50 for years 1, 2, and 5 post initial LT with an increase to 8/50 at year 7. GMFM scores improved from 65% at years 1 and 2 to 78% at year 5. At years 5 and 7, the child was able to perform trunk extension from forward flexed position, hold an upright posture without significant effort, lower the trunk into lying in a controlled manner up to 45°, and raise the head off the mat in an attempt to come to sit (Neuromuscular Recovery Scale). He expanded his locomotor skills in year 1 from walking to pedaling a tricycle, crawling, and stair-climbing and has retained these skills. At year 7, an adult "trike" was introduced and the child could independently pedal using direct drive, foot pedal straps, and a tractor seat. At every evaluation post LT, the child continued to ambulate independently with a rolling walker. With entry to middle school, he initiated use of a wheelchair at school only (year 7). He increased his step length and fastest gait speed with reverse rolling walker (0.5 m/s at year 1, 0.67 m/s at year 2, 1.1 m/s at year 5, and 1.15 m/s at year 7 post LT) and demonstrated reduced arm and trunk compensations while walking (year 5 and 7). During the year 7 follow-up, forearm crutches were introduced in lieu of the rolling walker. His fastest gait speed after 1 week of practice with the crutches was 0.65 m/s. Using the reverse rolling walker, the distance covered in the 6-Minute Walk Test increased from 163 m at year 5 to 185 m at year 7. The distance covered while using forearm crutches was 117 m. These recent developments (year 7) occurred despite recent demands for greater mobility at school and 2 surgeries (bladder/eye) (year 7), which had reduced the amount of time spent walking. His musculoskeletal health was negative for scoliosis and hip dysplasia (years 1, 2, and 5). Results from year 7 are pending annual x-ray assessment. Supramalleolar orthotics were added in year 5 for foot alignment. At year 7, orthoses were fabricated anew due to growth and use of a shoe insert with medial posting provided for the left foot as an alternative for use in the home. His height was within age appropriate norms (75th percentile at age 8 years, 50th at 10

and 12 years), but his weight percentile decreased (90th percentile at age 8 years, 95th at 10 years, to 25th at 12 years). MRI reports of lower extremity muscle composition and size and quality of life survey self-report (parent and child) comparing year 5 and year 7 will be provided. **Discussion:** At 12 years of age (pre-adolescent and 7 years post walking recovery), the child continues to walk with improved speed and endurance and reduced compensations. His new ability to walk with forearm crutches is expected to enhance his mobility as his skill and endurance improve and easier access to different environmental terrains is gained. The child has not developed the expected scoliosis and hip dysplasia post pediatric SCI occurring under age 5. In contrast, he has improved trunk control with normal physical growth profile, yet has a current personal goal of "improving core strength." With an increased demand for mobility at school to attend varied classrooms, the child initiated wheelchair use at school. Self-report from the family indicates the impact of convalescence post surgery on mobility appears to be negative and significant. While current outcomes are promising for changing the trajectory of recovery post pediatric SCI, the effects of adolescent growth spurts and social/educational demands will increase, necessitating vigilant monitoring of spinal alignment and mobility. Follow-up and ongoing reportage will continue until he is 18 years of age.

1008

Incidence of Chief Complaints and Retethering in Children with Lipomenigocele and Myelomenigocele

Haluk Altıok

Summary: *Recurrence rates for retethering release in patients with lipomenigocele were twice as high as those in patients with myelomenigocele. Patients with lipomenigocele presented with a chief complaint of foot deformity, while patients with myelomenigocele presented with progression of spine deformity as a chief complaint.* **Background:** After primary repair of myelomenigocele and lipomenigocele, late neurological deterioration

may occur secondary to tethering of the spinal cord. The purpose of the current study was to describe the difference in incidence and type of presenting signs and symptoms as well as recurrence rates between the 2 patient populations. **Methods:** Retrospective charts reviews were conducted for 65 patients who underwent tethered cord release between 1980 and 2010. Average age of patients with myelomeningocele ($n=43$) was 8.2 ± 4.5 years at initial tethered cord release surgery and 10.8 ± 5.5 years at retethering release. Average age of patients with lipomeningocele ($n=22$) was 6.4 ± 5.3 years at initial tethered cord release surgery and 9.3 ± 6.1 years at retethering release. **Results:** For patients with myelomeningocele, 9 of 43 (20.9%) required a retethering release after an average of 4.1 years due to continued symptoms. The most common presenting complaint was progression of spine deformity followed by changes in gait, spasticity, and weakness. For patients with lipomeningocele, 10 of 22 (45.5%) required a retethering release after an average of 4.1 years. The most common presenting complaint for this group was foot deformity followed by weakness and urodynamic changes. **Conclusions:** Recurrence rates for retethering release in patients with lipomeningocele were twice as high as those in patients with myelomeningocele. Patients with lipomeningocele presented with a chief complaint of foot deformity, which is consistent with previous studies. Contrary to other research, our patients with myelomeningocele presented with progression of spine deformity as a chief complaint.

1099

Long-Term Mental Health Outcomes of Individuals with Childhood-Onset Spinal Cord Injury

Kathy Zebracki

Summary: To assess mental health outcomes in adults with childhood-onset spinal cord injury and identify potential medical factors and coping responses predicting these outcomes. **Objective:** To assess mental health outcomes in adults with childhood-onset spinal cord injury (SCI) and

identify potential medical factors and coping responses predicting these outcomes. **Design:** Longitudinal follow-up, cross-sectional survey. **Participants/Methods:** Participants included 451 adults who sustained an SCI prior to age 18 (mean 13.9, SD 4.3; 0-17) and were former patients at 1 of 3 pediatric SCI programs within a larger US hospital system. Participants ranged from ages 18-48 years (mean 30.9, SD 6.1), tended to have complete injuries (AIS A, 70%) and tetraplegia (54%), and were predominantly male (63%) and Caucasian (84%). Participants completed measures assessing life satisfaction, depression, anxiety, coping, and general happiness. Descriptive, correlational, and regression analyses were used. **Results:** Hierarchical linear regression analyses for mental health outcomes revealed that after controlling for level of SCI injury, predictors such as medical complications (pressure ulcers and bladder/bowel accidents) and use of coping skills are significantly associated with depressive symptoms [$F(7, 332) = 19.11, P < .01$], life satisfaction [$F(7, 333) = 20.03, P < .01$], general happiness [$F(7, 119) = 7.88, P < .01$], and symptoms of anxiety [$F(7, 133) = 4.73, P < .01$]. **Conclusion:** This research suggests that medical complications in adults with SCI are related to important measures of psychological well-being. Furthermore, it is recommended that strategies to minimize medical complications and foster positive mental health outcomes should be considered.

Support: Shriners Hospitals for Children

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Long-term Outcomes of Individuals with Childhood-Onset Spinal Cord Injury

Lawrence C. Vogel

Summary: Review of long-term outcomes in adults with childhood-onset SCI in the areas of medical/secondary complications, pain, sleep, psychological functioning, substance use, employment, and sexual functioning/relationships. **Objective:** To assess long-term outcomes in adults with childhood-onset spinal cord injury (SCI) and to identify

potential demographic and medical factors predicting these outcomes. **Design:** Longitudinal follow-up, cross-sectional survey. **Participants/Methods:** Outcomes data will be presented from a prospective, longitudinal study of adults who sustained an SCI prior to age 18 (mean 13.9, SD 4.3; 0-17). Participants were former patients at 1 of 3 pediatric SCI programs within one hospital system in the United States, and included 449 individuals: ages 18-48 years (mean 30.7, SD 6.0), 63% male, 84% Caucasian, 70% AIS A, and 54% tetraplegia. Descriptive, correlational, and regression analyses will be used. **Results:** Presenters will discuss 6 domains critical to long-term outcomes in adults with childhood-onset SCI, including study overview (Vogel), medical complications (Hwang), pain and sleep (Zebracki), psychological functioning (Wasserman), substance use (Chlan), employment (January), and sexual functioning/ relationships (Vogel). All presentations will highlight subgroup differences, examine relationships between outcomes and key demographic and injury-related factors, and identify predictors of outcomes. When available, comparisons to published normative data will be made. **Conclusion:** Within each outcome domain, recommendations to improve clinical outcomes and reduce risk factors will be provided along with recommendations for future research directions.

Support: Shriners Hospitals for Children

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MRI in Spinal Trauma – A Predictor of Neurological Recovery

Rajeshwar Srivastava

Summary: *Use of magnetic resonance imaging appears to be of great help in diagnosing spinal trauma and correlating it with clinical profile and neurological outcome because of better contrast resolution, absence of bony artifacts, multiplanar imaging, and choice of pulse sequence in cases of spinal cord ischemia, hemorrhage, edema, and contusion.* **Data:** We performed this prospective study on 62 patients with acute spinal trauma. We

evaluated the epidemiology of spinal trauma and various traumatic findings by magnetic resonance imaging (MRI). The MRI findings were correlated with clinical findings at admission and discharge according to ASIA Impairment Scale. Four types of MR signal patterns were seen in association with spinal cord injury: cord edema/non-hemorrhagic cord contusion (CC), severe cord compression (SCC), cord hemorrhage (CH), and epidural hematoma (EH). Isolated lesion of cord contusion was found in 40%. All other MR signal patterns were found to be in combination. In CC, we further subdivided the group into contusion of size <3 cm and contusion of size >3 cm to evaluate any significance of length of cord contusion. In CH involving >1 cm of the cord, focus was said to be sizable. **Results:** On bivariate analysis, there was a definitive correlation of CC involving <3 cm and >3 cm of cord. In >3 cm, chances of improvement were 5.75 times less than in patients with CC involving <3 cm of cord (odds ratio [OR] = 5.75; 95% CI, 0.95-0.36; Fisher's exact $P = .0427$ [$P < .05$]). Presence of sizable focus of HC in cord (>1 cm) was most strongly associated with poor outcome. The risk of retaining a complete cord injury at the time of follow-up for patients who initially had significant hemorrhage in cord was more than 6-fold in patients without initial hemorrhage (OR = 6.97, $P = .0047$). It was noted that the patients in whom EH was present, no improvement was seen; however, by statistical analysis it was not a risk factor and was not related with the outcome (OR = 0.5, $P = .22$). Presence of severe cord compression (SCC) was a risk factor for poor outcome (OR = 4.90, $P = .0143$). **Conclusion:** On multiple logistic regression /multivariate analysis for estimating prognosis, sizable focus of hemorrhage was most consistently associated with poor outcome (OR = -6.73, $P = .32$). In severe cord compression, the risk of poor outcome was more (OR = 4.3, $P = .149$), however it was not statistically significant. Presence of cord edema/nonhemorrhagic contusion was not associated with poor outcome (OR = 0.25, $P = .178$). The risk of retaining a complete cord injury at the time of follow-up for patients who initially showed evidence of significant hemorrhage in cord was more than 6-fold in patients without initial hemorrhage (OR = 6.97, $P = .0047$).

1009

Post-Operative Scoliotic Curve Progression Following Tethered Cord Release in Children with Myelodysplasia*Haluk Altıok*

Summary: All patients who had tethered cord release immediately before their posterior spinal fusion had Cobb angles greater than 50°, whereas 48% of children in the conservative group ultimately required definitive spine surgery an average of 3.2 years following release, with a trend where tethered cord release alone was able to control scoliotic curve in children who had Cobb angles less than 45°. **Background:** New onset/progressive scoliosis can be the first sign of symptomatic tethered cord in patients with myelodysplasia. Release of the tethered cord may help to control the scoliotic curve progression. The purpose of the current study was to describe postoperative curve progression following tethered cord release in children with myelodysplasia who presented with new onset of progressive scoliosis. **Methods:** Medical charts of 96 patients who underwent tethered cord release between 1980 and 2010 were reviewed. Of the 33 patients (34%) that presented with a chief complaint of progressive spine deformity, 12 (average age 11.3 years) underwent further corrective spine surgery after the tethered cord was released while 21 (average age 6.2 years) were managed conservatively after tethered cord release. The conservative group consisted of 18 with myelomeningocele and 3 with lipomyelomeningocele. Twenty of these patients had scoliosis while 1 had kyphosis. Fifteen had associated ventriculoperitoneal (VP) shunt and Chiari malformation. **Results:** All 12 patients who had tethered cord release immediately before their definitive posterior spinal fusion and instrumentation had Cobb angles = 50°. Complications following tethered cord release included wound infection and diminished bladder control, which did not alter the outcome of the definitive spinal fusion. Forty-eight percent of the children in the conservative group ultimately required definitive spine surgery on an average of 3.2 years following release. Among the participants

in this group, a trend existed where tethered cord release, alone, was able to control scoliotic curve in children who had Cobb angles = 45° and a higher level of function (L5+). However, for children younger than 10 years old at the time of release, it was less likely for tethered cord release alone to control the curve. **Conclusions:** Early onset/progressive scoliosis could be an important indicator of tethered cord syndrome in patients with myelodysplasia. Tethered cord release may delay the definitive spine surgery, which can be important in a young patient population.

Measurement in Pediatric SCI

1049

Baseline Blood Pressure and Heart Rate in Children with Spinal Cord Injury*Miriam Hwang*

Summary: This study investigates baseline blood pressure and heart rate values according to age and injury-related factors in children and adolescents with SCI. **Objective:** The objectives of this study were to determine baseline blood pressure (BP) and heart rate (HR) measurements in youth with SCI, and to investigate differences in BP and HR in relation to age, gender, body mass index (BMI), and injury-related factors. **Design:** Retrospective review of medical records. **Participants/Methods:** Children and adolescents who had been admitted to 1 of 2 pediatric SCI specialty hospitals for inpatient rehabilitation. Medical records were reviewed to collect 3 consecutive days of morning and evening BP and HR. Mean BP and HR measurements were compared among 4 age groups (1: 0-5 years, 2: 6-12 years, 3: 13-15 years, 4: 16-18 years) and associations were determined with demographic and injury-related factors. **Results:** Medical records of 315 youth were reviewed: male, 59%; mean age, 12.3 ± 4.7 years; Caucasian, 75%; paraplegia, 66%; complete injury, 62%. Mean systolic BP (SBP, mm Hg) for groups 1-4 were 98.6 ± 6.7, 103.8 ± 7.0, 109.9 ± 8.9, 111.8 ± 9.4,

respectively ($P < .01$). Mean diastolic BP (DBP, mm Hg) for groups 1–4 were 57.9 ± 6.5 , 58.6 ± 5.1 , 61.6 ± 5.3 , 62.4 ± 5.2 , respectively ($P < .01$). Mean HR (beats/min) for groups 1–4 were 105.3 ± 22.6 , 90.2 ± 9.6 , 87.4 ± 11.6 , 81.6 ± 11.5 , respectively ($P < .01$). SBP was higher in boys and HR was higher in girls; SBP was higher in those with incomplete injury and paraplegia. SBP and DBP were positively associated with age and BMI; HR was negatively associated with age and BMI. There was no association between baseline cardiovascular measures and duration of injury. **Conclusion:** BP and HR are a function of age, injury severity, and BMI in youth with SCI. Awareness of baseline measures will allow for more effective management of cardiovascular complications, especially in youth presenting with atypical symptoms.

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Field Testing the WISCI-II and SCIM-III with Children with SCI

Christina Calhoun

Summary: This pilot study, looking at the reliability and validity of the WISCI II and SCIM III item 12, demonstrated high intra- and interrater reliability and concurrent validity, indicating preliminary utility for use with children. **Objective:** The objective is to evaluate the reliability of the Walking Index for Spinal Cord Injury II (WISCI-II) and Spinal Cord Independence Measure (SCIM) mobility indoors item (12) when used with children with spinal cord injury (SCI) and to examine the concurrent validity between the WISCI-II and the mobility indoors item on the SCIM in children with SCI. **Participants/Methods:** A convenience sample of 10 children with SCI between 5-13 years of age completed 2 trials of ambulation, for 10 meters, while being videotaped. Six raters,

all licensed physical therapists, trained in the WISCI-II and SCIM, independently scored the WISCI-II and SCIM mobility indoors item (12) for each of the subjects' 2 trials by reviewing the videotape. The viewing and scoring of trials 1 and 2 were separated by at least 3 weeks. Inter- and intrarater reliability was calculated using intraclass correlation coefficients (ICC) and 95% confidence intervals (CI). Concurrent validity was evaluated using the Spearman correlation coefficient. **Results:** Intrarater and interrater reliability of repeated WISCI-II scores was high (ICC = 0.98, 95% CI, 0.96-0.99; ICC = 0.98, 95% CI, 0.94-0.99, respectively). Intra- and interrater reliability for the SCIM mobility score was equally high (ICC = 0.98, 95% CI, 0.95-0.99). There was strong correlation between the WISCI-II and SCIM mobility item ($r_s=0.99$). **Conclusion:** In this sample of 10 children and 6 trained raters, intra- and interrater reliability of WISCI-II scores and the SCIM mobility indoors scores was high, providing preliminary indication for their utility with children. The high correlation between the WISCI-II and SCIM mobility item further supports concurrent validity.

1053

Pediatric Assessment of Manual Wheelchair Skills: Developmental Milestones

Pamela Wilson

Summary: This study is designed to develop a methodology for the assessment of manual wheelchair skill attainment in very young children. **Background:** Young children with mobility impairments frequently use wheelchairs as a method of navigating around the home and community. There are limited data available on the developmental acquisition of manual wheelchair skills in the very young child with a disability. For the adult wheelchair user, it is possible to use the Wheelchair Skills Test (WST), but we found that very early skills were not reflected in this tool. We therefore developed the Pediatric Assessment of Manual Wheelchair Skills (PAMWS). This

study was designed with 2 aims: to identify the wheelchair mobility developmental milestones in children with spinal cord injury (SCI) and spina bifida (SB), and to develop a tool that can adequately describe the extent of the skills attained and the developmental time course over which they are acquired. This study describes the early stages of development of a novel assessment tool for documenting wheelchair maneuvering skills with a goal of documenting age-related norms. **Methods:** Young children were recruited from a hospital-based SCI and SB clinic. The inclusion age range for this study was 9 months to 5 years. Once consent was obtained, the children were fit with a study wheelchair if they did not have their own equipment. Developmental Ages and Stages Questionnaire (ASQ) scores were obtained for each child. The PAMWS is based on clinician observation of 63 defined skills that are scored as absent, developing, or proficient (0-2). These skills are further divided into categories based upon their complexity and difficulty (pre-mobility, basic, and advanced). For this early study, each skill was observed by 3 clinicians. Each subject was then re-examined at subsequent regular clinic visits. **Results:** The subject population consisted of 7 males and 3 females with an age range of 15-54 months (mean 28.6; 13.7 months). The underlying diagnoses were SB in 9/10 children and SCI in the other child. Functional defined levels were 1 sacral, 4 low lumbar, 4 mid lumbar, and 1 high lumbar. ASQ scores placed all children out of the normal range on gross motor skills, 40% were below normal on communication, 40% were below for fine motor, 30% were below normal for problem solving, and 30% were below on personal and social skills. The study group means were higher on the premobility skill set than the basic skill set (1.64/0.45 vs 0.89/0.69; $P < .01$). No consistent scores were obtainable for the advanced skill set for this age range. To assess the impact of age on scores, subjects were divided into 2 groups (<24 months and 24-55 months) and their mean category scores were compared. For premobility skills assessment, there were no group differences. In the more complex "basic mobility" category, the 2 group means were statistically different (0.47/0.45 vs 1.51/0.44; $P < .01$). **Conclusions:** This study is the

first attempt to look in depth at manual wheelchair skill development in very young children with a disability. The preliminary data ($n=10$) suggest that the skill set design of the PAMWS is able to discriminate skill level based upon age. The study goal is to validate the PAMWS in addition to developing wheelchair skill milestones that families and therapists can use to predict timing of skills acquisition. Further work continues as more subjects are evaluated in different age groups, developmental change is monitored by repeat assessment, and the skill set categories are further refined.

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Prevalence of Vitamin D Deficiency in Youth with Spinal Cord Injury

Pamela Patt

Summary: *This abstract will illustrate the prevalence of vitamin D deficiency in youth with spinal cord injury and present a case for routine vitamin D assessment and education for all youth with SCI.* **Objective:** Determine the prevalence of vitamin D deficiency in youth with spinal cord injury (SCI). **Design:** Retrospective chart review. **Participants/Methods:** Youth with SCI who are currently followed at Shriners Hospitals for Children, Chicago. 25-hydroxyvitamin D [25(OH) D] levels were obtained during routine follow-up, with levels of < 32 ng/mL indicating suboptimal and < 20 ng/mL indicating deficiency. **Results:** Of 69 individuals (ages 3-21 years, mean age 14 years, 52% male, 72% White), 81% had suboptimal and 40.5% had deficient vitamin D levels. There were no significant differences in vitamin D levels in relation to level of injury (paraplegia/tetraplegia) or gender. There was a trend toward significance for race with White subjects at lower risk than non-White. This did not reach statistical significance. **Conclusion:** Suboptimal vitamin D levels are common in youth with SCI. Further study is needed to assess the significance of race and vitamin D levels and to assess the relationship of vitamin D levels with geographic latitude, body fat

percentage, bone density, occurrence of fractures, and calcium/vitamin D consumption. Diagnosis and management of vitamin D deficiency is particularly important in the pediatric population because of the extensive bone formation that occurs with growth.

1038

Upper Extremity Biomechanical Model for Evaluation of Pediatrics with SCI During Wheelchair Activities

Alyssa Paul

Summary: *Developing a pediatric model to quantify upper extremity biomechanics during manual wheelchair use of children with SCI should help reduce or eliminate commonly seen pain and pathology.* **Objective:** Quantify upper extremity biomechanics during manual wheelchair use of children with SCI. **Design:** Single subject. **Participants/Methods:** An upper extremity biomechanical model was created specifically for the pediatric population. A single 17-year-old male with SCI who uses a manual wheelchair was evaluated during manual wheelchair mobility. Twenty-seven markers placed on subject's hands, forearms, upper arms, scapulae, clavicles, and thorax were used in combination with a specialized wheelchair hand rim that records forces and moments (SmartWheel, Out-Front, Mesa, AZ) to quantify the joint motions and loads. Data were collected during 3 trials in which the subject propelled his wheelchair at a self-selected pace across a tile floor during 120 Hz motion capture and 240 Hz kinetic data capture. **Results:** Preliminary results analyzing 10 total wheelchair cycles show that the wrist joint was primarily subjected to tension forces along the medial-lateral and superior-inferior axes and compression forces along the anterior-posterior axis during wheelchair propulsion. The average maximum (SD) tension forces in the anterior-posterior (x-axis), superior-inferior (y-axis), and medial-lateral (z-axis) directions were 7.3 N (1.6), 24.4 N (9.5), and 38.3 N (6.8), respectively. The average maximum compression forces in the x-, y-, and

z-axes were -43.0 N (2.8), -4.49 N (2.2), and -6.3 N (1.8), respectively. **Conclusion:** Wrist joint forces experienced by the subject with SCI, in combination with large wrist extension, may be indicative of future wrist pathologies. An alternative propulsion pattern or method may be justified. Knowledge gained of upper extremity motions and loads experienced during wheelchair mobility should help reduce or eliminate pain and pathology commonly experienced in manual wheelchair users with SCI through varied propulsion patterns, rehabilitation intervention, or other measures.

Support: Shriners Hospitals for Children and National Institute on Disability and Rehabilitation Research.

1042

Wheelchair Kinematics for Individuals with Spinal Cord Injury

Adam Graf

Summary: *This study characterized upper extremity joint kinematics during wheelchair mobility.* **Objective:** The goal of this study was to characterize upper extremity joint kinematics during wheelchair mobility. **Design:** Cohort. **Participants/Methods:** Thirteen manual wheelchair users with SCI (age range 9-25 years) participated. Each subject propelled their wheelchair along a 15-meter walkway at a self-selected pace for multiple trials. Three-dimensional motion capture system (Vicon, Oxford Metrics, Oxford, UK) collected motion data. A custom upper extremity biomechanical model was then applied to the kinematic data to compute triaxial shoulder, elbow, and wrist joint angles. Push phase plus recovery phase defined 100% stroke cycle. Peak kinematics (maximum and minimum) within each phase and at initial rim contact were computed from 3 representative trials and averaged. Difference of the kinematic peaks determined the overall range of motion (ROM). **Results:** The mean ROM of the shoulders, elbows, and wrists were most notable in the sagittal plane. The greatest ROM occurred in shoulder flexion/extension (71.6°) followed by the wrist

(52.3°) and elbow (52.1°, flexion only). Peak flexion of the shoulder occurred during recovery phase (53.3°) and peak extension was during push phase (21.8°). Peak flexion of the wrist occurred during recovery phase (17.3°) and peak extension during push phase (35.8°). Peak flexion of the elbow occurred during push phase (71.0°). In the coronal plane, the shoulder was abducted and the wrist moved between radial and ulnar deviation. The shoulder and elbow were internally rotated in the transverse plane, while the wrist demonstrated small movements of internal and external rotation.

Conclusion: Inappropriate motion of the upper extremities during wheelchair propulsion may lead to pain and pathology in individuals with SCI. To prevent overuse syndromes and chronic upper extremity pain, it is useful to characterize upper extremity joint motions and forces during wheelchair propulsion. This will be helpful due to the altered mobility patterns and increased magnitude and frequency of joint loads in an extremely heterogeneous patient population. This model serves as the basis for developing a kinetic model for further insight to joint load demands during wheelchair mobility. Quantitative assessment of upper extremity joint kinematics may ultimately assist in wheelchair prescription, therapeutic planning, and clinical intervention for individuals with SCI.

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Nursing and Rehabilitation

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Early Initiation of Reciprocating Gait Orthosis Training in Pediatric Spinal Cord Injury: A Case Report

Maggie Lefever

Summary: *A reciprocating gait orthosis (RGO) provides children with the necessary support for standing and provides them with the opportunity to ambulate throughout their environment. The purpose of this case study was to investigate the readiness of a 2-year-old child to initiate mobility training with a RGO and track his progress over subsequent bouts of intensive rehabilitation.* **Background and Purpose:**

One goal of rehabilitation of a young child with a spinal cord injury is to enhance the child's ability to achieve upright standing and mobility. Depending on the degree of recovery and completeness of injury, the child may need an orthotic device to help achieve upright standing and mobility. A reciprocating gait orthosis (RGO) provides children with the necessary support for standing and provides them with the opportunity to ambulate throughout their environment with an assistive device. However, many children do not initiate RGO training until 4 or 5 years of age and use other devices for standing. The purpose of this case study was to investigate the readiness of a 2-year-old child to initiate mobility training with a RGO and track his progress over subsequent bouts of intensive rehabilitation. **Case Description:** The patient is currently a 5-year-old male who sustained a T2 spinal cord injury at 21 months of age secondary to a car versus pedestrian accident. He was admitted to Shriners Hospital for Children—Chicago for physical rehabilitation at 25 months of age and presented with complete sensory and motor loss and flaccid tone below his level of injury. Parapodium training was initiated during the patient's first visit at 25 months of age. The patient was measured and molded for a RGO during his second admission at 29 months of age and started ambulation training with the RGO at 32 months of age. **Results:** With continued

training, the patient was able to progress from requiring maximal assistance with the RGO and a wheeled walker to ambulating with forearm crutches and contact guard to minimal assistance by the time he was 5 years old. **Conclusion:** RGO training may be initiated as young as 2 years old to provide a child with a spinal cord injury the opportunity to achieve the desired goals of upright standing and mobility.

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Knowledge Levels of Staff, Parents, and Adolescents with Spina Bifida Regarding Tethered Cord, Shunt Malfunction, and Latex Allergy Symptoms

Ann Flanagan

Summary: *Knowledge levels of adolescents with spina bifida regarding tethered cord issues, shunt malfunction, latex allergies, and latex items is significantly low, with parents' knowledge presenting somewhat better and clinical staff knowledge presenting even higher at our institution.*

Background: Due to limited research, we sought to determine knowledge levels of hospital staff, parents, and adolescent patients with spina bifida (SB) regarding tethered cord (TC), shunt malfunction, and latex allergy symptoms. **Methods:** Demographic and knowledge surveys were completed by 53 hospital staff (7 M/46 F). During SB clinic, a convenience sample of 37 parents of children with SB (8 M/29 F) and 15 adolescent patients (average 15.3 years, 9 M/6 F) also completed surveys. **Results:** *Staff:* Clinical staff self-rated overall SB knowledge as at least fair. Incorrect responses to increased urinary tract infections (UTI), spasticity, and progressive foot deformities as possible TC symptoms and memory loss as a shunt malfunction symptom were seen for >35%. Over 70% incorrectly answered fever and sneezing as latex allergy symptoms. *Parents:* One quarter reported no knowledge of TC. Incorrect responses to increased UTI and progressive foot deformities as possible TC symptoms were seen for >68%. Parents of children with shunts reported >35% incorrect responses on all shunt items. Over

35% of parents did not know that eye irritation and wheezing were latex allergy symptoms or that disposable diapers, wheelchair and crutch parts, and sports equipment handles may contain latex. *Patients:* Fifty-three percent of patients had no knowledge of TC and answered all TC items incorrectly >60% of the time. Of the 47% of patients with shunts, >50% knew the malfunction symptoms of headache, nausea or vomiting, and redness or swelling along shunt track. However, <50% knew the remaining 8 common symptoms. Besides itching, >50% were unaware of any symptoms of latex allergies as well as items that contain latex. **Conclusions:** There were marked knowledge gaps for all groups in the areas of TC, shunt malfunction, and latex allergy. The adolescents had the least awareness. Improving education for all groups will be beneficial for the care of patients with SB.

1085

Effectiveness of Inpatient Hospital Stays for Self-Catheterization and Independence for Children with Spina Bifida

Rachel Galant

Summary: *We sought to determine if a short, intensive hospital stay would provide the tools for children/adolescents with spina bifida to be successful with self-catheterization.* **Background:** Individuals with spina bifida (SB) often have delays with activities of daily living (ADLs) and executive functioning, which makes independence training at home challenging. We sought to determine if a short, intensive hospital stay would provide the tools for children/adolescents with SB to be successful with self-catheterization. **Methods:** A retrospective chart review from 2007-2011 of 13 patients with SB (average age, 11.2 ± 2.4; 3 M/10 F) was completed. Each child was identified in clinic as a good candidate for catheterization training and participated in a 3-5 day hospital stay with twice daily occupational therapy (OT) services and nursing team teaching. OT utilized flash cards, teaching doll, anatomy review, and achievement charts and provided aids as needed. Readiness

activity skills included fine motor strengthening, dexterity, perceptual motor, visual perceptual, ADL, and bathroom transfers training. Data were collected prior to training, at discharge, and at a clinic follow-up. **Results:** Prior to training, 54% of participants were completely dependent for catheterization and 36% were dependent with catheter insertion but helped with pre-catheterization tasks. One participant continued to be dependent at discharge and follow-up due to anatomy and dependence in lower body self-help skills. At discharge, 31% required assistance with catheter insertion and cues for pre-catheterization tasks and 62% were independent except for verbal cues. At clinic follow-up (average 6.5 months), one participant required assist with catheter insertion and cues for pre-catheterization tasks, 23% were independent with catheter insertion with occasional cueing, and 62% were completely independent with all aspects. Fifty percent of participants used a mirror in bed to complete the task. Seventeen percent performed it in bed without aids, 17% used a toilet and mirror, and 17% used a toilet with no aids. **Conclusions:** Utilizing this unique model of intensive inpatient hospital stay and OT intervention, most participants with SB made excellent progress in self-catheterization independence and maintained or surpassed that level at follow-up.

1030

Implementing Transition to Adulthood as a Process: The New South Wales (Australia) Collaborative Approach

Marieke Mcphail

Summary: *The NSW Paediatric Spinal Outreach Service, Australia, has identified the need for a collaborative approach to transition across paediatric and adult services, utilising development of resources to facilitate information sharing and to determine goal setting based on assessment of transition readiness.*

Data: The transition of young adults from paediatric to adult services has increasingly been recognised as a process rather than an event (Ried, 2010). This awareness has enabled a shift in thinking about

transition from reactive planning in late adolescence to proactive planning for independence through childhood. The NSW Paediatric Spinal Outreach Service (PSOS), Australia, has implemented the “process model” of transition through use of directed independence-focused goal setting and a developmental approach to transition throughout childhood. Despite a conscious shift in service model orientation, many challenges remain in fostering readiness for transition in young adults with spinal injury. Recent legislation change in Australia has enforced medical transition at the event of the young adult’s 18th birthday, restricting flexibility in the health system for a transition process tailored to the individual. Conversely, adult services report they are not well equipped to support these young adults who are often still dependent on their parents and negotiating the school system. The handover process is therefore difficult at a service level, resulting in role confusion and uncertainty for young adults and their families. In response to the current issue around implementing the process model of transition, PSOS has sought a 2-pronged approach. Review of a range of best practice national and international resources that focused on steps to increase independence in children and young people has led to our own resource development. Special consideration was given to adapting (with permission) the Bloorview Kids Rehab Canada Growing Up Independently chart that outlines childhood stages based on developmental milestones that would be expected of children without a disability. Our adaptation is the Kids Spinal Cord Injury Living Skills (SCILS) for Life chart that assists transition education for families and young people, but also equips adult services with an understanding of the paediatric framework to enable appropriate goal setting with the young adult referrals. This resource development has led to cross-service implementation in 2012 of a collaborative model of transition between PSOS, the Sydney Children’s Hospital Network, and adult spinal services. Priority has been given to resource sharing and further development of an SCILS for Life checklist to be used as a guide for handover between services and to direct goal setting based on assessment of transition readiness. Services will work together to create an individualised

transition plan for each young person and will provide consultative support to one another around identified areas of need. It is hoped that through this collaboration, transition to adulthood will be the outcome of a holistic, developmental approach to maximising independence of the young person with spinal injury.

1054

Rehabilitation of Children with Acute Spinal Cord Injuries: The Importance of Considering Developmental and Psychosocial Factors

Michael Green

Summary: *This case demonstrates the importance of not only considering but directly addressing the developmental level and psychosocial aspects of care for children with spinal cord injuries.*

Data: The medical and rehabilitative care of a pediatric patient with an acute spinal cord injury (SCI) offers many challenges. As most pediatric practitioners are aware, there are not only patient factors to take into consideration, but family elements as well. The patient's psychosocial environment can have profound effects, in both positive and adverse ways, on the patient's course and outcome. The current poster presents a case study of a child with a new SCI. This patient highlights the importance of considering the developmental level and psychosocial factors in the care of the pediatric patient. The patient is an 11-year-old male who sustained a gunshot wound when shot by his younger sibling. The patient sustained multiple injuries, including multiple intra-abdominal organ injuries and L2 SCI. He initially presented with a T12 AIS A SCI while in spinal shock. Upon admission to the rehabilitation medicine service, his exam was more consistent with an L2 AIS C SCI, with minimal motor activity and severe neuropathic pain. With regard to psychosocial background, the patient is the oldest child in a single parent home. Mother has a history of substance abuse and psychiatric illness. The patient is a primary caregiver to his 3 younger siblings. When mother heard of the

patient's prognosis, she expressed her distress that her son would no longer be able to care for her. When learning of his own prognosis, the patient expressed suicidal ideation. He also experienced emotions of anger toward the sibling, whom he thinks shot him intentionally. He was distressed by the changes in his body, his intense neuropathic pain, and fear that he would die in the hospital. The patient also expressed feelings of abandonment from his mother who was absent from his bedside for extended periods of time. Hopelessness was a common theme for the patient, as he was resistant to nursing care, transitions, and attempts at new skills and activities. Thus, his progress was very slow. Watching other patients progress and discharge from the hospital only added to his feelings of abandonment, hopelessness for himself, and ultimately led to a decrease in his motivation to practice any challenging skills. Once he was able to build feelings of trust and support in his treatment team, his functional progress significantly improved. Addressing the patient's fears, issues of abandonment, and feelings of hopelessness, as well as teaching him healthier, age-appropriate coping strategies, improved his ability to participate in his therapies and nursing cares. His functional progress was directly linked to his perception of trusting and supportive relationships with his caregivers. A behavior management program, focused on the patient's participation in nursing care and therapies, was also developed to further encourage active involvement in his own rehabilitation. This resulted in him making observable progress in his functional skills and further helped the patient's motivation to continue to participate in his rehabilitation program. In reviewing the professional literature, there is limited information with regard to identifying the myriad psychosocial factors that may impact a pediatric patient's rehabilitation course and ways to address these factors. This case demonstrates the importance of considering and directly attending to the developmental level and psychosocial needs of the newly injured pediatric patient. Addressing these needs facilitates successful physical rehabilitation of the patient and ultimately the patient's overall outcome.

1019

The Kids SCILS (Spinal Cord: Independent Living Skills) for Life Chart

Mandy Hanna

Summary: *The Kids SCILS for Life resource aims to promote the development of independence in children and adolescents, with the aim of improving quality of life outcomes and readiness for adulthood.*

Data: Age-appropriate development of self-management skills and independence enables young people to effectively transition from paediatric to adult health services.¹ Australian research (NSW) on transition indicates that the movement between child and adult care is not optimal.² In addition, an identified lack of a well-planned and coordinated approach has further effected the successful transition of young people affected by SCI. To achieve an effective transition to adult health services, young people with an SCI need to be empowered and actively engaged through the transition process. The NSW Paediatric Spinal Outreach Service (PSOS), which is a part of Northcott Disability Services, Australia, developed the Kids SCILS (Spinal Cord Injury Life Skills) for Life chart as a tool that could be utilised with children, young people, their families, and service providers. This is an adapted model of the Bloorview Kids Rehab (Canada) Growing Up Ready timetable that was designed to help children and youth with disabilities to get ready for adult life through different ages and stages.³ Elements of the Kids SCILS for Life chart will be presented and recommendations for its utility will be explored. The chart encompasses the categories of parenting, play and leisure, education, body functions, self-care, mobility and exercise, and medical considerations according to age ranges. It is specific to SCI in childhood and youth and promotes family-centred practice. The Kids SCILS for Life chart aims to:

- Guide the practice of health professionals in the timing and type of age-appropriate skills and knowledge required for independence and adulthood, regardless of injury level,

- Foster a collaborative and consistent approach across all services involved in the care of children and young people with SCI,
- Provide a simple and informative guide to children, young people, and their families.

Ultimately, it is intended that the Kids SCILS for Life chart will promote the effective transition of young people from paediatric to adult health services and promote a life of health, satisfaction, and productivity. (Northcott Disability Services is an innovative and dynamic not-for-profit organisation that provides support to 10,000 people with a broad range of disabilities and their families and carers by offering a range of programs which promote a genuinely inclusive society.)

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1088

Use of the Assisting Hand Assessment to Capture Functional Change in the Affected Upper Limb in a Brown-Sequard Type SCI: A Case Report

Patricia O'Brien

Summary: *In this case study, we utilized the Assisting Hand Assessment to capture functional change in the upper limb of a 5-year-old girl with Brown-Sequard type spinal cord injury.* **Background and Purpose:** Standardized functional assessment of the upper limb in spinal cord injury is often a challenge. There is a lack of standardized assessment tools designed for this unique population. This challenge is elevated in the pediatric population. The Assisting Hand Assessment (AHA) is a play-based standardized assessment designed to evaluate

children ages 18 months to 12 years with unilateral upper limb impairment. The AHA uses bimanual tasks to quantify functional use of the impaired upper extremity and the interaction of the assisting hand with the dominant hand. Traditionally, it has been used in children with hemiplegic cerebral palsy and brachial plexus injury. The purpose of this case study was to investigate the usefulness of the AHA in the child with a motor incomplete cervical spinal cord injury. **Case Description:** The patient was a typically developing 5-year-old female who sustained incomplete cervical and lumbar spinal cord injuries due to a motor vehicle accident. She was admitted to Shriners Hospitals for Children–Chicago (SHC-C) for her initial inpatient physical rehabilitation. Upper limb function was consistent with a Brown-Sequard type lesion with the left arm affected. Functionally, she was noted to have weakness, synergistic movement patterns, and decreased awareness of the left arm, resulting in decreased spontaneous use (learned non-use) of the left arm and difficulty with bilateral activities. The AHA was first administered 3 months post injury, during her initial rehab stay. At this point, motor recovery had slowed. The patient was discharged home where she received traditional outpatient therapy. She returned to SHC-C for additional intensive rehabilitation 9 months post injury. Her motor exam revealed little to no changes in proximal strength and moderate changes in distal strength; however functional use of the limb appeared to have improved. The AHA was re-administered in an attempt to quantify these changes. **Results:** Despite limited changes in strength, the patient's scaled score on the AHA improved from 41% to 64% over a 6-month period. The most dramatic improvements were seen in the initiation of use of the limb, choosing to use affected limb when closer to desired item, and release skills. Positive changes were also seen in reaching skills, variety of type of grasp used, and object manipulation. **Conclusion:** By using the AHA, we were able to identify a positive functional change in the use of the affected limb, despite limited strength gains. The AHA should be considered as an effective tool in assessing upper limb function in motor incomplete pediatric cervical spinal cord injury.

Outcomes

1014

Comparison of Psychosocial Outcomes Between Youth with Early Onset Spinal Cord Injury and Those with Spina Bifida

Ann Flanagan

Summary: *Using standardized outcome tools to compare youth with spinal cord injury (SCI) and youth with spina bifida (SB) we found that youth with SCI and paraplegia who were injured before the age of 3 have greater school and overall health-related quality of life, participate in more diverse activities, and trend toward less anxiety and depression than those children with SB.*

Background: Understanding the psychosocial outcomes of youth with spinal cord dysfunction is critical to providing necessary supports and to designing appropriate interventions. **Purpose:** Identify differences in health-related quality of life (HRQOL), participation, and anxiety and depression between youth with spinal cord injury (SCI) who were injured before the age of 3 and youth with spina bifida (SB). **Participants and Setting:** 83 youth with SCI (49 M/34 F, average age 10.6 ± 3.8 years) injured before the age of 3; and 54 youth with SB (27 M/27 F, average age 11.7 ± 4.1 years) were enrolled. All youth were 5-18 years old at interview, spoke English, and had injury/motor levels that were tetraplegia (37%) or paraplegia (63%) for the SCI participants and paraplegia for the SB group. Youth with SCI were receiving care at 1 of 3 specialty hospitals and youth with SB were receiving care at only one of the specialty hospitals. **Materials/Methods:** Youth completed the following standardized measures: Children's Assessment of Participation and Enjoyment, Pediatric Quality of Life Inventory, Revised Children's Manifest Anxiety Scale, and the Children's Depression Inventory. Independent samples *t* tests and Mann-Whitney tests assessed group differences. **Results:** Youth with SCI had been injured an average of 10 ± 3.8 years. Eighty-seven percent of children with SB had a shunt with an average of 2 ± 2.8 revisions. The SCI group was 69.9% Caucasian and 70.4% of the SB group was

Caucasian. The SCI group (combined tetraplegia and paraplegia) injured before 3 years of age showed a higher school HRQOL ($P = .016$) and lower anxiety level ($P = .055$) than the SB group. The subgroup of SCI subjects with paraplegia ($n = 52$) demonstrated a higher school ($P = .014$) and overall ($P = .034$) HRQOL and greater diversity of activities ($P = .015$) for community participation than the SB group. Trends towards lower anxiety ($P = .076$) and depression ($P = .065$) were also seen for the SCI participants with paraplegia compared to the SB group. **Conclusion:** Youth with SCI and paraplegia who were injured before the age of 3 have greater school and overall HRQOL, participate in more diverse activities, and trend toward less anxiety and depression than those children with SB.

1012

Motor Contingency Learning and Infants with Spina Bifida

Heather Taylor

Summary: *This study evaluated motor contingency learning among 6-month-old infants with spina bifida and neurologically typical infants, a core skill that is essential for cognitive and motor control development.* **Background:** Infants' successful motoric organization and exploration of the environment is essential for cognitive development (Thelen & Smith, 1995; Thelen & Ulrich, 1991). Infants require sensory stimulation to trigger processes of neural development that will then affect the development of motor control. However, infants with spina bifida (SB) are at risk for sensory motor difficulties. Research suggests that motor functions requiring predictive signals and precise calibration of the temporal features of movement are impaired among individuals with SB. So, although children with SB learn discrete motor acts, they will have difficulty automatizing them into smooth and predictive motor acts, which provide the foundation for sensory-motor learning (Dennis, Salman, Juranek, and Fletcher, 2010; Dennis et al, 2004). However, little is known about early motor learning in SB and its relation to

the variable outcomes present at school-age and in adulthood that would have implications for early intervention. **Objective/Hypotheses:** The purpose of the current study was to assess motor contingency learning in infants with SB (using a conjugate reinforcement task) that requires the integration of motor and perceptual information (ie, learning a means/ends relation) and retention of learning when sensory feedback was absent in 6-month-old infants with SB and their typical developing (TD) peers. Based on the findings from studies of motor and sensory learning in school-age children with SB as well as our habituation studies of 18-month olds with SB, we hypothesized that (1) 6-month-old infants with SB would respond similarly to TD infants (show similar levels of arm waving) during acquisition reflecting the acquisition of the motor contingency in the presence of reinforcement; and (2) infants with SB who learned the contingency would show less retention of that learning over time than controls because they may have difficulty maintaining a response in the absence of sensory feedback/reinforcement. **Methods:** A sample of 98 infants (SB = 37; TD = 61) participated in this study. The infants with SB were referred to the study at birth by treating neurosurgeons and pediatricians in Houston, Texas, and southern Ontario. Infants with SB were compared to TD infants using a mobile conjugate reinforcement paradigm at 6 months of age to evaluate learning and retention of a sensory-motor contingency. Analyses evaluated infant arm waving rates at baseline (wrist not tethered to a mobile), during acquisition of the sensory-motor contingency (wrist tethered to mobile), and immediately after the acquisition phase and then after a delay, controlling for arm reaching ability, gestational age, and socioeconomic status. **Results:** Although both groups responded to the contingency with increased arm waving from baseline to acquisition, 15% to 29% fewer infants with SB than TD were found to learn the contingency depending on the criterion used to determine contingency learning. In addition, infants with SB who had learned the contingency had more difficulty retaining the contingency over time when sensory feedback was absent. The findings suggest that infants with SB do not learn motor contingencies as easily

or at the same rate as TD infants and have more difficulty retaining motor contingencies when sensory feedback is absent. **Conclusion:** Learning of the motor contingency requires the integration of sensory and motor information, which is then reinforced by sensory feedback (the mobile moves and makes a sound). Infants with SB may have difficulty shifting attention between motor information and sensory feedback as they do with shifting attention in other tasks (eg, Taylor et al, 2010). Infants with SB appear to respond to sensory feedback but lack the intact sensory-motor representations when feedback is absent. This suggests that infants with SB may demonstrate a disconnect between their arm movements and sensory feedback, which may in turn interfere with learning of causal relations linking action and perception. The importance of infants' perception of contingency information for later cognitive and social development is well established in the literature, indicating that contingency learning procedures might constitute one type of early intervention for infants with SB.

725

Motor Segmental Recovery in Spinal Cord Injury – A Blessing in Disguise!

Rajeshwar Srivastava

Summary: *A prospective longitudinal study to investigate the role of posterior instrumentation with laminectomy in neurological recovery of thoracolumbar spine injury.* **Purpose:** Our knowledge regarding neurological recovery following spinal cord injury is like the tip of an iceberg. Spinal cord does not regenerate once damaged but nerve roots do so if an optimum environment is provided. Although distal neurological recovery is unlikely in ASIA Impairment Scale A (complete lesions), root recovery at the site of injury can occur. ISNCSCI has recognized zone of partial preservation and zonal segmental recovery below the neurological level. Such a recovery in motor function (motor segmental recovery [MSR]) of lumbar roots in paraplegia may make all the difference in final

outcome of ambulation and functional status of the patient. **Method:** 100 thoracolumbar injuries in AIS A (complete lesions) underwent surgery. In 60, posterior instrumentation alone (Gp1) and in 40 posterior instrumentation with laminectomy (Gp2) was done. Results of these were compared with randomly picked up 100 similar cases treated conservatively (Gp3). Outcome measures were improvement in AIS by periodic recording of ISNCSCI sensory and motor scores. When AIS A recovered to AIS D/E, distal neurological recovery was said to be functional (FDNR). MSR was said to be significant (MSR-Sig) only when at least 2 key muscles had power of more than 3 on both the sides. **Results:** Merits of surgery (Gp1 & Gp2) over conservative (Gp3) were many in terms of reduction and stability, pain-function scores, total hospital stay, and ambulation mode and time. At 2-year follow-up, in Gp3 FDNR was 7% (7/100) and MSR-Sig was 40% (40/100). In Gp1 FDNR was 11.67% (7/60) and MSR-Sig was 68.33% (41/60). When laminectomy was added with instrumentation (Gp2), FDNR was 12.5% (5/40) and MSR-Sig was found in 92% (37/40) of cases. **Conclusion:** Laminectomy was a procedure condemned in the past. It was said that it produces posterior instability, converts a stable fracture into an unstable one, and had no added benefits. In our series of conservative versus surgery, when laminectomy was added to posterior instrumentation we found added advantages in terms of direct visualization of dura and roots to identify the extent of damage and provide posterior decompression of the cord. It is safe, easy to perform with few complications, and facilitates MSR of spared nerve roots in zone of partial preservation (ISNCSCI's zone of segmental recovery). Instability produced by laminectomy is well supported by posterior instrumentation when bone grafting is added. MSR was especially beneficial in thoracolumbar injuries where MSR-Sig of the L2 and L3 roots appear to make a difference between ability to ambulate (with braces) and full-time wheeled mobility.

1022

Outcomes Among Youth with Complete and Incomplete Spinal Cord Injury

Anne Riordan

Summary: *Differences in psychosocial outcomes, including participation, quality of life, and mental health, were investigated between youth with complete and incomplete spinal cord injuries, as assessed by the American Spinal Injury Association Impairment Scale (AIS).* **Background:** The current study examined differences in psychosocial outcomes between youth with complete and incomplete spinal cord injuries (SCI), as assessed by the American Spinal Injury Association Impairment Scale (AIS). Differences in participation, quality of life (QOL), and mental health were investigated.

Design: Survey research. **Methods:** Youth ages 5-18 years with SCI from 3 pediatric SCI centers completed the Children's Assessment of Participation and Enjoyment, which measures participation in informal and formal activities, according to 5 categories: recreational, physical, social, skill-based, and self-improvement; the Pediatric Quality of Life Inventory, a measure of emotional, social, and school QOL; the Revised Children's Manifest Anxiety Survey; and Children's Depression Inventory. One-way analysis of variance (ANOVA) and analysis of covariance (ANCOVA) tests were used to assess group differences, with the latter adjusting for age and injury level. **Results:** 368 youth participated; 57% were male, 65% Caucasian, mean age was 13.10 years (SD=3.92) at interview, 8.06 years (SD=5.87) at injury, and 66% had paraplegia. Fifty-five percent of youth had complete injuries (AIS A); of the 45% with incomplete injuries, 36% were classified as AIS B, 30% AIS C, and 34% AIS D. Youth with complete and incomplete injuries did not differ significantly in terms of sex, race, or ages at interview or injury, but youth with complete injuries were more likely to have paraplegia ($P = .004$). Youth with incomplete injuries participated in more activities ($P = .001$) and more often ($P = .036$). In contrast, youth with complete injuries reported higher social QOL ($P = .035$). No significant differences in mental health were reported. After adjusting for

age and injury level, only the difference in number of activities persisted ($P = .002$). Specifically, youth with incomplete injuries participated in more informal ($P = .004$) and formal ($P = .035$) activities, particularly around recreational ($P = .032$) and skill-based ($P = .002$) activities. **Conclusion:** Completeness of injury is related to participation but not QOL or mental health among youth with SCI. In particular, youth with incomplete injuries participated in more activities. Interventions should target youth with complete injuries and aim to encourage participation in a greater number and variety of activities.

Support: This work was supported by Shriners Hospitals for Children, grant 9143.

1048

Outcomes of Caregivers of Youth with Spinal Cord Dysfunction

Erin Kelly

Summary: *In this investigation of caregiver outcomes, compared to caregivers of youth with spina bifida, caregivers of youth with spinal cord injury (SCI) were more anxious and depressed and were more likely to be receiving treatment for mental health issues. Caregivers of youth with SCI may be in particular need of support after their child's injury.* **Objective:** To examine outcomes of caregivers of youth with spinal cord injury (SCI) and spina bifida (SB) and to assess relationships between caregiver and child outcomes. **Design:** Survey research. **Participants/Methods:** English-speaking caregivers of youth ages 1-18 with SCI or SB completed anxiety/depression measures. Youth completed age-appropriate measures of psychosocial health. Analyses included independent samples t tests, chi-square analyses, and Pearson correlations. Time since injury and current age were used to calculate duration of disability for youth with SCI and SB, respectively. **Results:** 419 caregivers participated: 78% mothers, 68% married, and 66% some college. Youth were an average age of 10.82 (SD=5.12); 343 had SCI and 76 SB. Youth with SCI had been injured an average of 5.67 years

(SD=4.79) and 64% had paraplegia. Thirty-two percent of youth with SB had motor levels of L2 or higher, 65% L3-L5, and 3% S1 or lower. Overall, 18% of caregivers experienced moderate/severe anxiety and 21% moderate/severe depression. Caregivers of youth with SCI were more anxious ($P = .016$) and depressed ($P = .003$) than those of youth with SB. Further, more caregivers of youth with SCI received counseling and/or took psychotropic medications ($P = .014$). Injury levels of youth with SCI were higher than motor levels of youth with SB ($P < .001$). Youths with SCI were older ($P < .001$) with shorter duration of disability ($P < .001$). However, these 3 variables were not related to caregiver outcomes. Among youth with SCI, caregiver anxiety/depression were related to lower child QOL ($P < .001$; $P < .001$) and higher child anxiety ($P = .001$; $P < .001$) and depression ($P < .001$; $P < .001$). Among youth with SB, there were no relationships between caregiver and child outcomes. **Conclusion:** Caregivers of youth with SCI appear to be at increased risk for anxiety and depression. Caregiver anxiety/depression may be more detrimental to youth with SCI than SB; relationships should be explored with larger samples.

Support: Shriners Hospitals for Children 9143.

1032

Preventing Primary Spinal Cord Injuries in Adolescents: A 7th Grade Science Education Program

Cindy Hartley

Summary: Review of an implemented and assessed education program addressing the impact of a spinal cord or brain injury and injury prevention for 400+ middle school students. **Data:** All 7th grade students (400+) enrolled in a single middle school received a 3 week educational series about brain and spinal cord anatomy and function, expected changes following injury, and injury prevention. The curriculum was developed by a team of clinicians and educators including physical and occupational therapists, speech and language

pathologists, counselors, therapeutic recreation specialists, school teachers, and hospital/school system administrators. The curriculum was interactive including video case studies and school visitation with former patients who have a brain and/or spinal cord injury. Students were tested for knowledge of the affects of these injuries, and a visual analogue scale (VAS) was used for a pre and post course attitude assessment of the students' perceptions of risk for 20 behaviors, such as not wearing a helmet while on a bike. Results from our pilot program in 2011 and current findings from 2012 will be reviewed and compared. Based on findings from the pilot, in which there was an 84% increase in perceived risk on the post assessment, changes were necessary to the pre and post tests, as well as the delivery format of the educational program. Data are currently being compiled for 2012; however preliminary findings also indicate a positive change in perceived risk behavior. This program does demonstrate that education sessions can improve a student's knowledge of the impact of a brain or spinal cord injury and change perceived attitudes about the risk of common behaviors.

1101

The Diagnostic Accuracy of Diffusion Tensor Imaging for Spinal Cord Injury: Preliminary Analysis of Sensitivity and Specificity

M.J. Mulcahey

Summary: Determine the accuracy of diffusion tensor imaging as a diagnostic tool for spinal cord injury. **Objective:** Determine the accuracy of diffusion tensor imaging (DTI) as a diagnostic tool for spinal cord injury (SCI). **Design:** Prospective cross-sectional sample of 10 subjects with chronic cervical SCI and 25 subjects without SCI underwent scans using a 3.0T Siemens Verio MR scanner. The imaging protocol consisted of conventional sagittal fast spin echo (FSE) T1- and T2-weighted scans, axial FSE T2-weighted scans, and axial DTI acquisition. DTI mean and standard deviation values for subjects with MRI evidence of SCI were compared to values for subjects without

SCI. Sensitivity, specificity, and area under the receiver operating characteristic curve (ROC AUC) were calculated. **Results:** The mean values for fractional anisotropy (FA) and mean diffusivity (MD) for subjects without SCI were $0.51 \pm .08$ and $0.60 \pm .15$. The mean values of FA and MD for subjects with SCI at MRI level of injury were $0.23 \pm .13$ and $1.06 \pm .51$, respectively. The mean values of FA and MD for subjects with SCI above the MRI level of injury were $0.35 \pm .08$ and $0.67 \pm .30$, respectively. Sensitivity, specificity, and ROC AUC for diagnosing MRI abnormal level using FA, axial diffusivity (AD), and radial diffusivity were 0.89, 0.85, and 0.92 (95% CI, 0.90-0.94), respectively, and for the diagnosis of abnormal motor level based on the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) they were 0.85, 0.86, and 0.92 (95% CI, 0.90-0.94), respectively. **Conclusion:** There is a difference in mean DTI values between subjects with and without SCI. This difference is seen above and below the MRI-defined level of injury. Specificity and sensitivity of DTI for MRI and ISNCSCI motor abnormal level were high. These data provide preliminary evidence of DTI accuracy for diagnosing SCI.

Support: The project was funded by Shriners Hospitals for Children grant 70015.

1100

Validity of Computer Adaptive Tests of Mobility, Activity Performance, and Participation

M.J. Mulcahey

Summary: *Examine the validity of newly developed computer adaptive tests of mobility, activity performance, and participation for child- and parent-reported outcomes after spinal cord injury.*

Objective: Examine the validity of newly developed computer adaptive tests (CAT) of mobility, activity performance, and participation for child- and parent-reported outcomes after spinal cord injury (SCI). **Design:** Prospective, cross-sectional sample of 100 children between 8 and 21 years of age with

SCI and 101 parents of children with SCI were administered 15-item CATs of mobility, activity performance, and participation and the Functional Independence Measure (FIM), FIM+5, Spinal Cord Independence Measure (SCIM), and the Pediatric Quality of Life Inventory (PedsQL). Concurrent validity between the CATs and legacy measures were evaluated using the Pearson product-moment correlation coefficient (r). **Results:** The sample consisted of an equal number of males (50.41%) and females (49.59%) with slightly more complete (54.47%) and thoracic level (53.66%) injuries. There was a strong positive relationship between the child-reported mobility CAT and the FIM ($r=.83$), FIM+5 ($r=.86$), SCIM mobility ($r=.81$), and SCIM total ($r=.85$) and between the child-reported activity CAT and the FIM ($r=.85$), FIM+5 ($r=.88$), SCIM self-care ($r=.84$), and SCIM total ($r=.81$). There was a moderate positive relationship between the child-reported participation CAT and the FIM ($r=.67$), FIM+5 ($r=.68$), SCIM self-care ($r=.59$), SCIM mobility ($r=.48$), and total SCIM ($r=.58$). The relationship between the child-reported CATs and PedsQL was weak ($r=.40-.42$). Similar relationships were seen between parent-reported CATs and legacy measures. **Conclusion:** Newly developed child- and parent-reported CATs of mobility, activity, and participation demonstrate acceptable-to-strong concurrent validity with legacy measures, with strongest relationships seen between the CATs of mobility and activity and the FIM, FIM+5, and SCIM. The weak relationship between the CATs and the PedsQL may be an indication of the known limitation of the PedsQL with children with SCI. These data provide building evidence in support of the psychometric properties of the CATs.

Support: The project was funded by Shriners Hospitals for Children grant 9146.

1058

Blue Crew: Adolescent Services at Magee Rehabilitation Hospital, Philadelphia, PA

Brian Comly

Summary: *Blue Crew is an adolescent focused specialty educational and functional activity group that facilitates a supportive structure for those individuals to attain skills for community re-entry.*

Data: The Blue Crew program is an adolescent educational and functional activity program to assist individuals with physical disability including spinal cord injury (SCI) with community re-entry. This includes returning to high school, college, technical school, employment, and recreational activities. Magee Rehabilitation Hospital is a 96-bed acute rehabilitation hospital assisting individuals with physical disabilities such as SCI, traumatic brain injury, stroke, as well as other diagnoses. Magee is one of the 16 Model Spinal Cord Injury Centers sponsored by the National Institute on Disability and Rehabilitation Research. Magee is also home to the first CARF-accredited brain injury rehabilitation program in the nation. All adolescent patients meet with an adolescent counselor to coordinate various services. Educational and recreational services are introduced early on in the rehabilitation process. As a result, a high percentage of our high school students with an SCI have gone on to graduate from high school with their class, and they were likely to go on to higher education. An early introduction to recreational services has also led to getting involved with wheelchair sports, volunteer as mentors, and seek employment. Vocational rehabilitation counseling and referrals to the appropriate state vocational rehabilitation agencies has been a critical component in successfully returning to the community. We intend to demonstrate our statistical information via a poster/eposter along with photos of individuals with an SCI, showing the importance of introducing vocational, educational, and recreational services early for a successful community re-entry.

1092

Rehabilitation After Recurrent Ependymoma in a 13-Year-Old Female: A Case Report

Erika Erlandson

Summary: *Describe the rehabilitation of a 13-year-old girl with recurrent metastatic ependymoma after multiple surgical resections, chemotherapy, and radiation treatments resulting in significant morbidity.* **Background:** Ependymoma is a rare cause of tumors in children, with spinal cord lesions being the most uncommon location of presentation.¹ Metastatic ependymoma is even rarer, with incidence ranging from 9%-20%.² Research to date on ependymoma has clearly shown surgery to be the mainstay of treatment. However, despite the evidence for radical surgical clearance of ependymoma, there are little data on the cost of surgery in terms of neurologic deficit.³ Halmorsen et al found 28% of patients with spinal cord ependymoma had either newly discovered neurologic deficit and/or deterioration of a preexisting deficit in the immediate postoperative period. These were permanent in 67% of cases and transient in 33%.⁴ Regardless of this evidence, there have been no studies on rehabilitation of neurologic deficits and other morbidities associated with the treatment of ependymoma. This case study describes the rehabilitation of a 13-year-old female with multiple morbidities associated with treatment of her recurrent spinal cord ependymoma. **Significance for SCI Practice:** Ependymoma is a rare but important cause of spinal cord injury in children. Spinal cord rehabilitation is an important aspect to the multidisciplinary treatment and recovery of these patients and to maintain their functional independence. On admission to acute rehabilitation, our patient had significant weakness and parasthesias in the right upper and lower extremity, significant gait abnormality, decreased proprioception and sensory loss in the left arm and leg, and required assistance for all activities of daily living. In addition, her mobility and transfers were affected by orthostatic hypotension secondary to injury to her spinal cord and complicated by surgical debulking. At the

conclusion of her rehabilitation, she was able to ambulate independently with a straight cane and complete all activities of daily living with adaptive equipment. **Conclusion:** Ependymoma is an important cause of spinal cord injury in children and adults. Treatment includes surgical resection, chemotherapy, and radiation, which all result in varying degrees of morbidity. Rehabilitation is an important aspect of multidisciplinary treatment and recovery of these patients.

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Rehabilitation Paradigms for Recovery of Motor Function

1044

Activity-Based Restorative Therapy in Pediatric Transverse Myelitis: A Retrospective Cohort Analysis

Cristina Sadowsky

Summary: *This paper will describe and demonstrate improvements in pediatric patients with transverse myelitis receiving intensive outpatient activity-based restorative therapy and compare these patients with an established historical cohort. Objective:* To describe and demonstrate improvements in pediatric patients with transverse myelitis (TM) receiving intensive outpatient activity-based restorative therapy (ABRT) and to compare these patients with an established historical

cohort. **Design:** Retrospective cohort analysis. **Participants/Methods:** Twenty-eight cases of pediatric patients with TM were reviewed. Of these, 15 experienced onset of the disease before age 12 years, and 13 experienced onset between ages 12 and 18 years. Patients were seen for therapy 1.5 to 116 months postonset (mean 24 ± 92 months). On average, they received 43 hours of therapy (± 342 hours), or the equivalent of 10-13 days. Therapy interventions included activities of daily living (ADL) and functional skills training, functional electrical stimulation ergometry, neuromuscular electrical stimulation, partial body weight-supported gait training, overground gait training, aquatic therapy, functional mobility, supported standing, therapeutic exercises, static and dynamic balance training, and stretching. Patients were assessed before and after ABRT intervention with the American Spinal Injury Association Impairment Scale (AIS), the Modified Ashworth Spasticity Scale (MASS), the Short Form SF-36, and Spinal Cord Independence Measure (SCIM). Prior to beginning therapy, 78% of these patients had pinprick sensory deficits, 75% had light touch sensory deficits, 57% had a lower extremity motor score (LEMS) greater than 10, and 42% had a LEMS less than 10; 50% were nonambulatory and 71% required intermittent catheterization. Our cohort's neurological and day to day function was roughly equivalent to the available historical cohort data.¹ Initial AIS exams indicate that 8 patients were classified as AIS A, 1 patient was classified as AIS B, 12 patients were classified as AIS C, and 7 patients were classified as AIS D. **Results:** Following ABRT intervention, only 6 individuals were classified as AIS A, 2 as AIS B, 10 as AIS C, and 10 as AIS D, indicating neurological improvement. Whereas the motor scores barely changed (mean of 59 prior to intervention, 60 post intervention), the light touch and sensory scores improved to a greater extent (preintervention 73 and 80, respectively; postintervention 76 and 85, respectively). The mobility subscore of the SCIM improved from 19 to 21. The MASS score (assessed bilaterally in biceps, triceps, pectoralis, wrist flexors/extensors, finger flexors, hip flexors/extensors, thigh adductors, knee flexors/extensors, and ankle plantar and dorsiflexors) improved

from 30 to 28, despite decreases in antispasticity medication. SF-36 scores improved from 53 to 67. Following ABRT, 50% of the individuals experienced further improvements in self-care skills, 34% of them further improved their sphincter control, 25% improved in transfers, and 29% improved in locomotion, as measured by the SCIM. **Conclusion:** This cohort analysis indicates that both functional and neurological changes can occur in pediatric patients with TM following ABRT, even long-term after the neurological injury occurred. Patients receiving ABRT demonstrate better neurologic status and functional skills after therapy, as compared to historical cohort data. These changes were observed following a limited bout of therapy and provide good support for further studies, including those assessing dosing and intervention efficacy.

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706

An Interdisciplinary Approach to Treatment of Conversion Motor Paralysis Through Activity-Based Rehabilitation: A Case Series

Danielle Wilt

Summary: *Following intensive interdisciplinary inpatient rehabilitation, using activity-based rehabilitation paired with behavioral intervention and family education, 3 patients with conversion motor paralysis recovered complete motor function and successfully re-integrated into home, school, and community life.* **Background:** Conversion disorder is a psychiatric condition with physical manifestations. The most dramatic type of conversion disorder, conversion motor paralysis, involves motor symptoms, including weakness or paralysis. While these cases are relatively rare and can be difficult to diagnose, in part due to the necessity to rule out any possible

organic causes, they pose a unique challenge to health care providers. On clinical examination, symptoms are suggestive of neurologic conditions, although findings are inconsistent with expected presentations. Historically, patients diagnosed with conversion disorder have been treated using a mental health model. Consistent with most recent studies, this presentation examines the effectiveness of treatment for conversion motor paralysis in a rehabilitation setting. **Method:** A case review was conducted on 3 patients who were admitted to an intensive, interdisciplinary inpatient rehabilitation program for an average of 17 days (range, 14-21 days). Activity-based rehabilitation, a treatment approach used with patients with comparable neurologic conditions, was used to address physical dysfunction with an emphasis on systematic progression of physical abilities, participation in activities of daily living, and structured re-integration into community activities. Concurrently, patients received intensive individualized cognitive-behavioral therapy to develop active coping and pain management strategies (ie, distraction, focused breathing, progressive muscle relaxation, biofeedback, etc). Preferred coping and pain management strategies were identified for each patient and strengthened through verbal instruction, modeling, behavioral rehearsal, and positive reinforcement. Additionally, a structured behavioral program was utilized by staff to differentially reinforce and shape functional behavior for each patient. Family members underwent instruction on how to differentially reinforce their child's coping and participation while refraining from attending to pain and illness behavior. **Results:** Outcome measures, including WeeFIM, mobility and self-care, strength, and balance assessments, indicate significant improvement in function following inpatient admission. At admission, patients presented with varying degrees of lower extremity weakness or paralysis, ranging from non-ambulatory and wheelchair bound, to ambulating short distances (4 steps to 40 feet) with a walker; patients ranged from set-up assistance to modified independence at the wheelchair level for activities of daily living. At discharge, all patients were independently ambulating without

an assistive device and were independent with all activities of daily living. All patients returned home and transitioned back to school. At 1 year follow-up, WeeFIM scores remained at total independence in mobility and self-care skills indicating the long-term, successful integration of rehabilitative and psychological strategies into the home environment. **Discussion:** The benefit of an inpatient rehabilitation admission involves an environmental shift that removes the patient from various family and psychosocial stressors for a brief period of time. It offers reassurance to patients and their families that treatment includes both physical and psychological intervention to address their limitations. Rehabilitation promotes independent behavior and gradual progress in both physical and psychological recovery. It is of equal importance for gains to be made in a controlled and positive environment. Family therapy and education is imperative for successful re-integration back into the community.

897

Intensive Inpatient Activity-Based Rehabilitation Promotes Recovery of Ambulation Following Acute Pediatric Spinal Cord Injury

Meredith Bourque

Summary: *This case series describes 15 patients who were able to become functional ambulators during intensive activity-based inpatient rehabilitation.*

Objective: Demonstrate early recovery of and predictors for functional ambulation following intensive inpatient activity-based rehabilitation in pediatric patients with spinal cord injury (SCI).

Design: Retrospective case series. **Participants/**

Methods: This case series describes 15 patients, ages 6-19 years, with acute SCI (7 traumatic and 8 nontraumatic), who demonstrate significant motor recovery and became primary ambulators. Each patient participated in 2 to 3 hours of physical therapy and 1 to 2 hours of occupational therapy a day, 6 days per week. At time of admission, all patients relied on full-time use of a wheelchair. Therapy interventions included functional electrical stimulation ergometry, neuromuscular

electrical stimulation, partial body weight-supported gait training, overground gait training, aquatic therapy, functional mobility, supported standing, therapeutic exercises, static and dynamic balance training, and stretching. Standardized outcome measures included the ISNCSCI lower extremity motor score, Walking Index for SCI II (WISCI II), Pediatric Functional Independence Measure (Wee-FIM), the Six-Minute Walk Test (6MWT), the Spinal Cord Independence Measure, Timed Up and Go, and Berg Balance Scale. Patient statistics of this case series were then compared to total patients admitted between the ages of 6-19 years during the time period of 9/1/2009 to 5/12/2012. **Results:** At time of discharge, these patients were primary ambulators. Our patients demonstrated clinically significant improvements in the listed outcome measures assessing functional mobility. Patients demonstrated an average increase in ISNCSCI motor score of 16 points from admission to discharge. These patients resumed independent living, returning to home and school. **Conclusion:** This study illustrates that intensive activity-based rehabilitation immediately following SCI in children can improve functional mobility and recovery of ambulation. We predict that increases of at least 8-10 points in ISNCSCI lower extremity motor score within the first 30 days of intervention is a positive predictive factor of recovery of ambulation. In addition, we suspect that positive changes in the WeeFIM, 6MWT, and WISCI II within the first 60 days of intensive rehabilitation are predictors for identifying primary ambulators. These results provide a basis for further studies on the effect of intensive activity-based rehabilitation and children with acute SCI in order to better define treatment protocols that are most efficacious.

1061

Locomotor Training Effects on Functional Mobility, Health, and Emotional Well-Being in Three Adolescents with Incomplete Spinal Cord Injuries—A Case Series

Elizabeth Watson

Summary: *The purpose of this case series is to describe the effects of locomotor training delivered in an outpatient therapy setting on gait, balance, overall health, and participation in school and community activities in 3 adolescents with incomplete spinal cord injuries.* **Background/Purpose:** Rehabilitation of children following a spinal cord injury (SCI) has traditionally focused on the use of compensatory strategies. Over the past decade, there has been a shift in adult neurorehabilitation after SCI from the sole use of compensatory strategies to a focus on promoting recovery of neuromuscular activity below the level of the lesion. Locomotor training (LT) is an activity-based therapy that aims to retrain walking and postural control after SCI and is an effective intervention strategy with adults with incomplete SCI. The purpose of this case series is to describe the effects of LT delivered in an outpatient therapy setting on gait, balance, overall health, and participation in school and community activities in 3 adolescents with incomplete SCI. **Procedures:** Patients were recruited from centers participating in the NeuroRecovery Network (NRN). Inclusion criteria included a history of nonprogressive spinal cord lesion above T11, discharged from inpatient rehabilitation, and a medical referral by a physician. Standardized selection, evaluation, treatment, and discharge criteria were utilized and patients participated in LT following the program protocol. Patients were evaluated using standardized outcome measures focusing on neuromuscular control, motor, balance, walking, and functional skills. All procedures were in compliance with the institutional review boards of each NRN site. **Intervention:** All 3 patients participated in 90-minute sessions, consisting of 60 minutes of training on the treadmill with partial body weight support and 30 minutes of assessment overground and integration of skills into community/home

activities. Training strategies were adapted to improve motivation of the adolescent patients while addressing the specific goals. Parents were involved in instruction for carryover of skill acquisition in the home. Goals were determined with patient and parent input, and any medical concerns were documented and monitored throughout the intervention period (eg, pain, spasticity). **Case Descriptions:** Patient X was a 15-year-old male diagnosed with a T5 AIS D injury following a snowboarding accident. He initiated LT 3 months after injury, completing 75 sessions over 7 months. Goals included returning to school at an ambulatory level, walking from school to the sports field to help coach, and return to drumming in his band. Patient Y was a 14-year-old male diagnosed with T5 AIS C paraplegia due to AVM rupture. He began LT 11 months after injury and completed 3 separate bouts of LT lasting 1 month, 5 months, and 15 months, respectively. His goals were to walk without assistance and return to school. Patient Z was a 14-year-old male diagnosed with C4 AIS D SCI sustained during a football game. He initiated LT 2 months after injury and received 45 sessions over 9 weeks. This patient's specific goals were to walk without dragging his foot and without falling. **Outcomes:** Both Patient X and Y transitioned from being primary manual wheelchair users to ambulating independently with bilateral single point canes (SPC) in the community. Patient X also walked in his home without an assistive device (AD). Patient Z, who was ambulatory without an AD prior to training, reduced his gait deviations of left genu recurvatum and left toe drag. All 3 patients demonstrated improvement with ambulation speed as measured on the 10-meter walk test. Patient X improved from 0.16 m/s with a rolling walker (RW) to 1.22 m/s without an AD; Patient Y from 0.12 m/s with a RW to .45 m/s with B SPCs; Patient Z from 1.3 m/s without AD to 1.72 m/s. Berg Balance Scale (BBS) scores improved from 8/56 to 48/56 and 7/56 to 31/56, respectively, for Patients X and Y while Patient Z reached a ceiling effect, scoring 55/56 at his initial evaluation. All patients reported improved social participation and were able to return to school, sports, or other age-appropriate social activities. These adolescents were weaned from antispasticity and anti-

cholinergic medications. Further medical issues, such as changes in bladder and bowel management and musculoskeletal issues, will be discussed.

Discussion: These cases demonstrate that LT can be effectively applied for rehabilitation of adolescents resulting in meaningful improvements in balance, ambulation, and participation in school and community. Progression in therapy was within the context of multiple strengths and challenges commonly present among pediatric patients, including physical functioning during therapy, motivation and emotions, and family support. Developmentally appropriate adaptations to the therapy and parental involvement appear critical to success of therapy and will be discussed. Qualitative reports from adolescent patients suggested that returning to ambulatory levels with less restrictive assistive devices, without bracing, and with increased gait speed resulted in improved self-esteem, allowing them to increase their participation in their premorbid social activities and to set future personal goals to integrate more fully in the community.

1071

Locomotor Training Promotes Walking in Young Children with Severe, Chronic Spinal Cord Injuries Despite Disparate Etiologies and Prior Walking Experiences

Dena Howland

Summary: *Examples are presented to compare locomotor training effects (activity-based therapy) in 2 young children with diverse SCI etiologies and walking experiences prior to injury who responded to locomotor training by recovering independent walking with reverse rolling walkers.* **Data:** Reports from a number of laboratories, including ours, show that locomotor training (LT) enhances stepping and voluntary walking in adults with spinal cord injuries (SCIs). Typically, adults targeted for this approach have isolated voluntary lower extremity (LE) movements with lower extremity motor scores (LEMS) >20/50. As walking recovers and/or improves, LEMS increase

in this population. Key to LT used by our group is the afferent input generated through patterned stepping that is designed to activate circuitry within the caudal spinal cord below lesion level. Stepping is reinforced by intense daily, cued repetition on the treadmill followed by transfer and practice of skills in an overground environment. The transfer to overground also encourages the activity of descending supraspinal contributions. Currently, only our case study reports restoration of walking in a child with chronic SCI (Behrman et al, 2008; Fox et al, 2010). We have continued to use this approach in a small group of children with severe, chronic SCIs with the goal of understanding the potential application of LT in a pediatric population. Based upon clinical criteria, these children with little to no isolated voluntary LE movements (LEMS 0-8) are not predicted to recover walking. Examples are presented to compare LT effects in 2 young children with diverse SCI etiologies and walking experiences prior to injury who responded to LT by recovering independent walking with reverse rolling walkers. At 5 months of age, 1 child developed transverse myelitis resulting in a severe incomplete SCI. He enrolled in our LT study 3 years later (AIS C, C6) at 3½ years of age, with a LEMS of 0/50. The other child suffered an accidental gunshot wound at 3½ years of age that also resulted in a severe incomplete SCI. He enrolled in our study 16 months after his injury (AIS C with bilateral C7 function) at age 4½ with a LEMS of 4/50. This child who had experienced walking, running, bike riding, and tree climbing prior to injury showed the first indication of walking recovery during the fifth week of training. In contrast, the other child who had no prior experience walking showed the first indication of augmented stepping approximately 11 weeks into LT. The child with the initial LEMS of 0 improved to 4/50 when stepping developed, while the other showed no change and maintained a LEMS of 4/50. Both children showed lower extremity multi-joint synergies that could be voluntarily elicited over time. These movements were characterized by co-contraction of flexor and extensor muscles. Although manually cued walking on the treadmill was characterized by alternation of muscle groups, during independent ambulation with a walker

both children showed co-contraction during the stance phase that was particularly pronounced in distal musculature. This co-activation was consistent with activity patterns seen during LE synergistic movements during manual muscle testing. Comparison of stepping kinematic features revealed similarities and differences. Each showed compensatory trunk movements, lower extremity adduction, and minimal dorsiflexion. However, each also developed the ability to initiate consistent reciprocal stepping as well as the ability to adjust stepping speed and height overground. Assessment of modular control based upon combinations of weighted muscle contribution indicated that these children use 2 modules to walk. This is in contrast to the 4 seen in neurally intact children. Both children showed evidence of functional reticulospinal connections to the lumbar spinal cord. These connections were not seen in children who did not recover stepping abilities. No evidence for motor-evoked potentials in the lower extremities were seen in any of the severely injured children, except one child who did not recover stepping, suggesting corticospinal connections in the caudal cord are not necessary to mediate walking recovery in these children. Although LT did not promote walking in all children studied, it did enhance trunk control during sitting in all children. In summary, our findings suggest that LT has potential to benefit children of diverse ages, with varying prior walking experiences, SCI etiologies, and time since injury. Voluntary, isolated leg movements may not be required, but whole limb extensor synergy and tracts not typically identified with walking may be critical to recovery and predict potential to respond to LT. In addition to the primary goal of LT, walking, this treatment approach enhances trunk and postural control in nonwalking activities and can be effectively used in children as young as 3 years of age.

1067

Minimizing Bracing and Maximizing Functional Recovery in a 12 Year Old with Chronic SCI Utilizing Locomotor Training

Ashly Chadwell

Summary: *We report on the effect of activity-based therapy and locomotor training on functional improvement in a 12 year old with chronic SCI.*

Objective: To report effect of activity-based therapy and locomotor training on functional improvement in a 12 year old with chronic SCI. **Design:** Case study. **Setting:** Outpatient rehabilitation in the Christopher and Dana Reeve Foundation NeuroRecovery Network (NRN) at The Wexner Medical Center at The Ohio State University. **Case Description:** Twelve-year-old female with history of C2 spinal cord tumor removal at age 6 followed by a C2-6 cervical fusion at age 8. At baseline, the patient wore a thoracolumbar sacral orthosis (TLSO) during the day and a Providence brace at night (bracing 24 hours/day). She has worn these braces for 6 years and 3 months as recommended by her physician for prevention of progression of scoliosis and avoidance of surgical intervention. She ambulated with bilateral Lofstrand crutches and bilateral supra-malleolar orthoses (SMOs). She required assistance with dressing, bathing, and meal preparation. Her personal goals were as follows: (1) "I don't want to use my crutches at school anymore." (2) "I don't want to wear my back brace or ankle braces anymore so I can wear jeans and cute clothes." (3) "I want to do everything by myself." Her parents concurred with the patient's personal goals. **Interventions:** She completed 60 sessions of locomotor training (LT) in the NRN consisting of manual-facilitated standing and stepping on a treadmill with partial body weight support (BWS) (55 minutes/session), assessment overground, and reintegration of skills into home and community activities (30 minutes/session) 5 times a week. All treatment was performed without bracing. Goals in the treadmill environment for standing and stepping include maximizing lower extremity (LE) weight-bearing and maximizing task-specific sensory input, posture, and kinematics. The overground component followed

treadmill training and focused on activity-based training of functional tasks with assist provided when needed to minimize compensation and maximize neuromuscular recovery below level of injury. Some tasks practiced were donning and doffing articles of clothing including items with buttons and zippers to progress to independence with dressing, ambulating without crutches, floor transfers, and stair negotiation. Home program development enabled her to integrate learned principles and abilities into the home and community environments. **Main Outcome Measures:** Berg Balance Scale, 6-minute walk test (6MWT), 10-meter walk test (10MWT), Modified Functional Reach, ASIA Impairment Scale (AIS), and Neuromuscular Recovery Scale (NRS). **Results:** AIS: She converted from an AIS C to an AIS D. *Treadmill Assessment:* On initial evaluation during manual-assisted step training, the child ambulated at 35% BWS and 2.0 mph with independence and appropriate alignment of trunk. She was unable to achieve independence at the pelvis at a BWS >45% at speeds 0.8-1.0 mph. Initially, she could only ambulate for 3-4 minutes at a time during treadmill step training. Post intervention, she can ambulate at 2.2 mph and 12% BWS with trunk, pelvic, and bilateral LE independence at 0.9 mph at 15% BWS. She can also ambulate without the support of the harness (0% BWS) or manual assist at 0.4-0.5 mph with independence at the trunk, pelvis, and bilateral LEs. Post intervention, she was able to ambulate continuously for 55 minutes during treadmill step training without rest at various speeds from 0.9-2.2 mph with varied BWS at 0%-20%. *Overground Walking Assessment:* Prior to intervention, the child ambulated with bilateral Lofstrand crutches and SMOs with significant compensation. She leaned on the crutches with decreased step length, no heel strike, anterior center of gravity (leading with chest), marked flexion at the knees, tibial external rotation, and hip adduction. She used momentum (increased speed), especially when ambulating without crutches, to advance her lower extremities due to an inability to achieve and maintain appropriate weight-shift. Post intervention, she ambulates the majority of the time without the crutches or TLSO. She continues to use orthotics

(for proper alignment and prevention of overuse injuries). During the 6MWT with bilateral Lofstrand crutches, she can now achieve heel strike 75% of the time, maintain a neutral pelvis, and achieve and maintain equal weight shifts and equal stride lengths. Post intervention, she demonstrated decreased compensatory techniques and more fluid gait pattern during the 6MWT and she was able to complete the 6MWT without her crutches for the first time. *Overground Functional Assessment:* Prior to intervention, she was unable to grab a can of soda with her left hand and bring it to her mouth to take a drink; she is now able to complete the task independently with minor wrist compensatory techniques. She was unable to button up a shirt prior to the start of this program and now with increased time can button a shirt. Prior to intervention, the child was unable to maintain sitting posture with appropriate trunk and position of pelvis for greater than 1 minute. In sitting, she now is able to attain and maintain appropriate posture at trunk and pelvis indefinitely and is able to return to appropriate sitting posture after reaching forward in all directions greater than 10 inches. Prior to intervention, she required the use of her upper extremities to stabilize herself in a static standing position with increased lumbar lordosis, anterior pelvic tilt, increased hip and knee flexion, and pronated ankles (without SMOs and TLSO). Post intervention, she is able to maintain standing balance with appropriate posture at trunk and pelvis, with relaxed upper extremities, and appropriate knee extension and position of ankles (with bilateral orthotics, but without TLSO or SMOs). In addition, she is now able to maintain balance during dynamic activities, such as kicking a ball or shooting a basketball, with appropriate posture and kinematics, including ability to weight shift properly. Her Berg Balance Score improved from 32 to 42. *Community Integration:* She no longer needs to use her crutches during school. She can now independently negotiate a flight of stairs with use of a unilateral handrail, as well as complete dressing, bathing, and simple meal preparation independently. She is not wearing her TLSO the majority of the day, and updated x-rays demonstrated no change in her scoliotic curve (initially 19°; post treatment 17°). However, her

physician recommended that she wear the TLSO throughout the day with the exception of physical therapy or exercising for fear that a growth spurt would progress her scoliosis and require surgical intervention. **Conclusions:** The NRM LT program markedly improved overall function, ability to achieve and maintain appropriate posture, endurance, and balance, allowing for improved independence in the home and the community. She was able to minimize the use of her TLSO and SMOs, as well as her crutches for ambulation. With a home exercise program, she is able to continue utilizing learned abilities and principles to maintain functional independence. The patient is scheduled for a 6 month and 12 month follow-up for continued assessment of her overall function.

917

Spinal Shock in Spinal Cord Injuries: Is Duration of Shock Related to Neurological Level?

Rajeshwar Srivastava

Summary: A study was done to determine the duration of spinal shock in spinal cord injury, the first reflex to return while recovering from spinal shock, and the factors influencing duration of spinal shock.

Methods: One hundred sixteen patients in spinal shock following SCI were included. A detailed neurological examination of sensory, motor, and reflex activity was done every day until the patients were out of spinal shock. The duration of spinal shock by appearance of any reflex, the first reflex to return, and the influence of variable factors on duration of spinal shock were studied. **Results:** In 76 patients (85.4%), anal wink (AW) was the first reflex to return either alone or simultaneous with bulbo-cavernosis/delayed plantar response (BC/DPR). Cremastic reflex was the first reflex to return in 7 patients, pathological reflexes in 3 patients, and deep tendon reflexes (ankle) in 2 patients. Mean duration of spinal shock (MD of SS) was shorter in children, in malnourished, in untrained/laborers, in patients admitted early, and in patients without any complications. MD of SS was not influenced by sex of patient, associated

injuries, or different modalities of treatment.

Conclusion: On statistical analysis of duration of spinal shock with neurological level as a variable, MD of SS was 1.7 days in cervical cord lesions, 8.2 days in upper thoracic, 15 days in lower thoracic, and 17 days in lumbar cord lesions. Such an arithmetical progression was also found at each segmental level, ie, the duration of spinal shock progressively increased at every segmental level. MD of SS was 1.36 days at C4, 1.60 at C5, 1.72 at C6, 8.1 at T6, 12.4 at T8, 13.1 at T10, 15.3 at T12, and 21.6 at L2. An arithmetical relationship exists between the duration of spinal shock and the segmental level of spinal cord injury; the duration of spinal shock was directly proportional to level of injury. The higher or more proximal the lesion, the shorter the duration. We do not have the answer for this important observation. Does the duration of spinal shock depend on the cord length or neuronal mass involved or spared?

705

Wheelchair Prescription and Spinal Cord Recovery: A Case Series of Pediatric Patients with Acute Paraplegia

Elizabeth Farrell

Summary: This case series describes the clinical decision-making process behind wheelchair prescription in 2 pediatric patients with acute spinal cord injuries who experienced neurological recovery following intensive activity-based rehabilitation.

Purpose: This case series describes the process of wheelchair prescription in 2 pediatric patients with acute spinal cord injuries (SCIs). Following intensive inpatient activity-based rehabilitation (ABR), the patients in this case series experienced spinal cord recovery as demonstrated by an improvement in their American Spinal Injury Association Impairment Scale (AIS) classification. Both of these patients underwent a comprehensive seating evaluation during their inpatient rehabilitation admission that resulted in a wheelchair prescription. Wheelchair prescription in acute SCI reflects the patient's current positioning needs and allows for maximal

independence with mobility both in the home and in the community. **Method:** Patient A was a 17-year-old female with a C7 burst fracture and SCI following a motor vehicle collision 5 months prior to the admission. She initially presented with a C8 AIS B SCI. Following 4 weeks of intensive inpatient ABR, she improved the AIS classification to T1 AIS B. Seating evaluation during the course of her inpatient rehabilitation resulted in the prescription of an ultra-lightweight manual wheelchair with a 12-in. solid back and power-assisted wheels. This configuration allowed for maximal independence at discharge. Additionally, it allowed for adjustability as the patient continued to, neurologically and functionally, recover. The 12-in. back height was initially set high, at the scapular level, to allow for increased trunk support in the acute stage and over time was lowered to maximize scapular mobility and improve efficiency with wheelchair propulsion. The prescription also included power-assisted wheels, which provided the patient with increased independence given her decreased strength and impaired cardiovascular endurance while preserving the integrity of her shoulder joints. These wheels also allowed for adjustability with neurological recovery, as they could easily be removed when the patient demonstrated improvements in strength and endurance. Patient B was a 14-year-old female with SCI secondary to a T9 to T10 herniated disk with cord compression 2 weeks prior to this admission. She initially presented with a T9 AIS B SCI. Following 8 weeks of intensive inpatient ABR, she improved to a T10 AIS C SCI. Seating evaluation during the course of inpatient rehabilitation resulted in the prescription of an ultra-lightweight manual wheelchair with a 16.5-in. solid back and swing-away lateral supports. This configuration allowed the patient to be independent with wheelchair mobility upon discharge from acute inpatient rehabilitation while allowing for adjustability with neurological recovery; the swing-away lateral supports could be removed as the patient improved her strength and trunk control. **Results:** The patients described above underwent intensive inpatient ABR within 6 months from sustaining an SCI. Each youth underwent a comprehensive wheelchair evaluation and received recommendations based on current

level of function. Additionally, each seating recommendation considered maximal adaptability to allow for increased activity and independence in the event of spinal cord recovery and improved function. **Conclusion:** During wheelchair evaluation for the child and youth with acute SCI, it is important to consider adjustability and activity. The wheelchair prescription must allow for maximal independence with mobility at the patient's current functional level. Adjustability of the seating system is necessary as the patient may present with improved function as a result of neurological recovery. Key components of the seating system that allow for adjustability include lateral supports, positioning supports embedded in the backrest or cushion, height adjustable backrests, adjustable axel plates, and an adjustable back angle. The seating system could be configured to provide opportunities for activation of the trunk and upper extremities and further increase the potential for improved function with neurological recovery. It is paramount for the patient to maintain an active trunk, both for ongoing strengthening and to optimize independence within the home, school, and community environments.

1001

Gait Analysis in Patients with Lumbar Myelomeningocele After Training with Robotic Orthosis

Cristina Calzada

Summary: *The objective of this study was to identify whether there is an improvement in the gait of patients with lumbar myelomeningocele after training with robotic orthosis.* **Introduction:** Myelomeningocele is a group of disorders of neural tube development, characterized by imperfect fusion of the neural structures, mesenchymal bone, and the mid line. Children with high and low lumbar levels have better social adaptation and integration by achieving standing and walking assisted by long or short orthotic and walker. Thus, restoration of mobility is one of the main objectives in neurological rehabilitation, and for this purpose the spectrum of therapies to improve has increased

significantly. **Objective:** Identify changes in gait after gait training in robotic orthotic in the motion analysis laboratory. **Material and Methods:** A clinical, randomized, self-controlled, longitudinal, prospective study. Temporal parameters were measured (percentage of support and swing phases) and spatial (stride length, speed) before and after training were measured by assessing the existing changes. **Results:** Four patients met the criteria: 2 male, 2 female. Significance was shown in the variables analyzed for both feet support phase ($P = .0013$, $P = .0008$), swing phase ($P = .0163$, $P = .0025$), stride rate ($P = .0299$, $P = .0273$), and stride length ($P = .0146$, $P = .0113$). **Conclusion:** Training with a robotic orthosis in these patients improved gait pattern.

967

Intensive Inpatient Activity-Based Rehabilitation Leads to Significant Neurological and Functional Recovery in Adolescent Females: From Wheelchair to Walking

Julie Cagney

Summary: *This poster describes the case of 2 adolescent females who underwent intensive inpatient activity-based rehabilitation and recovered from ASIA Impairment Scale A to C and returned to ambulation as their primary means of mobility.*

Objective: To demonstrate rate of functional recovery associated with intensive inpatient activity-based rehabilitation (ABR) in adolescents with complete spinal cord injury (SCI). **Design:** Retrospective case review. **Participants/Methods:** Two adolescent females with initial diagnosis of ASIA Impairment Scale (AIS) A SCI participated in 3 to 4 hours of physical and occupational therapy per day, 6 days per week. Patient A was a 16-year-old female, acutely diagnosed with a T11 AIS A SCI secondary to motor vehicle accident, admitted 10 days post injury. Patient B was a 14-year-old female, acutely diagnosed with a T9 AIS A SCI secondary to a fall, admitted 6 days post injury. Both patients were nonambulatory and unable to bear weight through their lower extremities

at initial evaluation in the subacute setting. Interventions included functional training for self-cares, transfers/bed mobility, and other functional mobility; therapeutic exercises; splinting for joint preservation to promote optimal muscle/tendon lengths and to maintain or improve range of motion; and electrical stimulation for range of motion, neuromuscular re-education, prevention of muscle atrophy, spasticity management, and pain management; gait training; and aquatic therapy. The following data were collected via chart review: Manual Muscle Test scores, WeeFIM scores, balance measures, 6-Minute Walk Test, Walking Index for Spinal Cord Injury II (WISCI II), and Berg Balance Test. **Results:** At discharge from Kennedy Krieger Institute, Patient A was assessed as a T11 AIS C and was ambulating with bilateral Lofstrand crutches and a right solid ankle-foot orthosis (AFO). Patient B was assessed as a T10 AIS C and was ambulating with bilateral Lofstrand crutches and bilateral hinged AFOs with dorsiflexion assist and plantar flexion stops. Both patients resumed independent living, returning to home and school. The following objective measures were observed to have increased significantly from admission to discharge: Manual Muscle Testing in bilateral knee extension improved from 0/5 to >3/5, bilateral hip flexion from 0/5 to >2/5, WeeFIM functional mobility scores (including rolling, scooting, and transfers) improved from 1 to 7, WeeFIM mobility scores (including ambulation) improved from 1 to 6, and the WISCI II increased from 0 to 12. **Conclusion:** In these patients, intensive ABR led to significant neurological and functional recovery following acute SCI. Additional research, involving a larger sample, is needed to reflect outcomes generalizable to pediatric patients with SCI. Further evaluation of outcomes would be useful in determining most efficacious interventions for acute rehabilitation.

1011

Lower Extremity Muscle Activation Is Greater During Locomotor Tasks Compared with Tests of Voluntary Isolated Joint Movements in Children with Severe, Incomplete Spinal Cord Injury

Emily Fox

Summary: Children with severe, chronic incomplete spinal cord injury (AIS C, >1 year) exhibited greater muscle activation during a variety of locomotor tasks, compared with tests of voluntary, isolated joint movements, suggesting that the task-specific sensory inputs associated with locomotion are a potent stimulus for muscle activation below the level of the spinal cord lesion. **Data:** Following spinal cord injury (SCI), tests of voluntary, isolated joint movement and strength are used to assess descending supraspinal input to the lower extremities (LE). Currently, such outcomes are used to determine rehabilitation needs and predict walking function. Walking, however, also is controlled by spinal neural networks and sensory input. In adults with SCI, walking-related sensory input can induce greater activation of muscles below the spinal cord lesion than clinical tests of voluntary isolated joint movements. Ongoing work in our laboratory also suggests muscle activation may be more responsive to locomotor-specific sensory input in children with incomplete SCI (ISCI). Therefore, the purpose of this study was to compare LE muscle activation during tests of voluntary, isolated joint movements with muscle activation during a variety of locomotor tasks. We hypothesized children with ISCI would demonstrate greater muscle activation during locomotor tasks and that the greatest activation would occur during locomotor tasks requiring LE weight-bearing. Five children with severe, chronic (>1 year), ISCI (ASIA Impairment Scale C) (5 males; 9 ± 3 years of age) were evaluated. Electromyograms (EMGs) were recorded in 6 LE muscles during attempted isolated joint movements (hip flexion, knee extension, ankle dorsiflexion) and a variety of locomotor tasks (supine reciprocal LE flexion/extension, pedaling, treadmill walking, overground walking [$n=2$]). Mean amplitudes of EMGs were

calculated and compared. Mean amplitudes of EMGs recorded during the locomotor task were greater than amplitudes during attempted isolated joint movements ($P < .05$). During the tests of attempted voluntary, isolated joint movements, the children either were unable to move or they performed synergistic, multi-joint movements. Across locomotor tasks, mean EMG amplitudes were greatest during tasks requiring LE weight-bearing ($<.05$). Amplitudes were highest during treadmill and overground walking. The results indicate muscle activation during tests of voluntary, isolated joint movement in children with ISCI may not reflect the potential to activate LE muscles during upright, weight-bearing locomotor tasks. These findings suggest tests of LE muscle activation in children with ISCI should include assessments of activation during locomotor tasks. Weight-bearing locomotor tasks provide sensory input that may enhance or modulate the activation of muscles below the spinal cord lesion. Thus, interventions aiming to promote LE muscle activation after pediatric ISCI should incorporate weight-bearing locomotor tasks.

Evidence-Based Pediatric Spinal Cord Injury Medicine

1025

Family-Centred Care in a Children and Young Persons Spinal Cord Injury Setting

Allison Graham

Summary: In addition to the clinical knowledge and skills that any child-centred spinal rehabilitation centre delivers to achieve an optimal clinical outcome, it is essential that the service works to achieve the minimal impact on the family. **Objective:** To determine the extent that the children's and young persons' SCI unit delivered family-centred care as described by Koop 1987. **Design:** Family-centred audits based on the measured process of care (MPOC) performed provided a base for an outcome-based case note audit reviewing

the family construct after the completion of spinal rehabilitation following cord impairment. **Participants/Methods:** Initial information on the perception of provision of family-centred care was obtained from the initial audits from family members and staff, which identified some areas of good practice but other areas for further work. This did not help determine whether the rehabilitation had minimized the disruption to the family as a result of injury to their child, so further parameters were reviewed by standardized retrospective case note audit. **Results:** Eighteen new lesion patient clinical notes with complete data were reviewed from a 10-year period. Length of stay ranged from 61-690 days. One hundred percent of children returned to full-time education; 73% of children returned to the same school as prior to injury; and 28% of children had to repeat an academic year. Only 67% returned to the same family members in the home as prior to injury. Thirty-three percent of children returned to a different home address than their original home. **Conclusion:** The majority of children return home to the house they knew before injury, to the same school and neighborhood. Children with higher level of lesion experience more disruption to home and school life and had longer hospital stays. The study had small numbers and assumes that school and home are key proxy markers of family-centred care.

1081

A Novel Surface Electromyography-Based Brain-Computer Interface Utilizing a Single Head Muscle

Loren Davidson

Summary: *Explores the use of a single facial muscle to control a computer cursor and access electronic devices for mobility and environmental control.*

Introduction: This study explores the clinical utility of a novel brain-computer interface (BCI) using selective firing of a head muscle to control a computer cursor. The goals of this work are to allow individuals lacking the ability to move their limbs to control a computer, access electronics,

and drive power wheelchairs. Required hardware includes surface electromyography (sEMG) electrodes, a small battery pack, and a cellular android phone. The phone serves as the central processing unit (CPU) and, in addition to decoding the electrical signal, allows access to Bluetooth wireless technology to control nearby electronics. Preliminary work with this BCI by Joshi et al involved 4 able-bodied adults and 1 patient with advanced spinal muscular atrophy (SMA) learning to contract the auricularis superior (AS) muscle (Perez-Maldonado et al, 2010; Vernon & Joshi, 2011). This vestigial muscle, which allows people to wiggle their ears but does not serve a functional purpose, was thought to be an ideal candidate, as its use for alternate tasks would not impair daily function. In addition, the location of the AS above and behind the ear allows unobtrusive placement of sEMG electrodes. **Methods:** We designed a pilot case study in which a biofeedback protocol was used to train a subject to volitionally contract his AS muscle and modulate the power in 2 separate frequency bands, which in turn would navigate a computer cursor in 2 dimensions. After the training protocol, this ability was tested using a random target generator on the smart phone display. The patient repeatedly moved the cursor while the trajectory of the cursor path and percentage of successful target hits was recorded. **Results:** The test subject not only learned to volitionally contract his AS muscle, but he also demonstrated the ability to navigate a mobile phone displayed computer cursor in 2 dimensions using the BCI. The subject increased his percentage of targets successfully with each learning session, and comparison of cursor trajectories indicated that the subject moved with intentionality rather than at random. **Discussion:** This pilot study suggests that anyone with intact facial muscle control can manipulate a cursor in 2 dimensions using this BCI coupled with specialized biofeedback training protocol. Ultimately, the BCI via smart phone hardware will be used to access stationary electronic devices, environmental controls, and even control a power wheelchair, which will serve as potential additional outcome measures for future studies. At time of abstract submission, adults and children with spinal cord injury (SCI) were actively being

enrolled to examine the ability of this user group to control the novel BCI device. This subset of the disabled population are the most profoundly impaired, as they are dependent on others for nearly all activities of daily living. Innovation in the care of these patients resulting in greater independence has the potential to have profound impact on quality of life. Fundamental to this work will be patient satisfaction and comparison to current commercially available control devices.

1098

Advances in the Care of the Spine in Chronic Spinal Cord Injury

Randel Betz

Summary: *The purpose of this presentation is to discuss some new concepts for both nonsurgical and surgical care of the spine in individuals with chronic spinal cord injury (SCI).* **Data:** The purpose of this presentation is to discuss some new concepts for both nonsurgical and surgical care of the spine in individuals with chronic spinal cord injury (SCI). Spine deformity develops after SCI in over 90% of children and adolescents, and the risk of progressing to surgery when the injury occurs before skeletal maturity is approximately 67%. Prophylactic bracing beginning at the time of injury may prevent surgery in approximately 50% of patients. If it does not, it can delay it an average of 6 years, allowing the child to grow to a more adult height. Bracing plays a lesser role in curves 21° to 40° and probably no role in curves >40°. Despite some success with prophylactic bracing, there are issues with compliance and decreased work space. Indications for surgery include curves >40° in the growing child, preferably >10 years of age, and functional problems or pain in those who have already reached skeletal maturity. Outcomes after spinal fusion generally report 92% satisfaction with minimal decrease in function. However, activities probably require more effort and, therefore, most patients prefer their prefusion flexibility. It is important to maintain the sagittal sitting position of the spine with special rod bending during surgery, especially for patients

who are dependent on compensatory strategies for hand to mouth movement. An investigational treatment of correction of spine deformity without fusion (wedge osteotomies) has been shown to be safe and moderately effective. Approximately 5% of adults with chronic SCI acquire scoliosis. Unique to patients with paralysis is the Charcot spine, which requires an aggressive early surgical approach. Delay or failure to treat can result in patients losing spasticity or function. In summary, children and adults with chronic SCI can benefit from new operative and nonoperative strategies for treatment of their spinal deformity.

1083

Dorsal Rhizotomy for Management of Spasticity in Traumatic Paraplegia

Teresa Massagli

Summary: *Dorsal rhizotomy was successful in controlling spasticity and spasms in a child with paraplegia who obtained only temporary relief with phenol and botulinum toxin A blocks.* **Data:** Spasticity and spasms are common sequelae of spinal cord injury (SCI) in children. Depending on the clinical scenario, treatments may include passive range of motion exercises, oral medications, chemodenervation, and intrathecal baclofen pumps. Selective dorsal rhizotomy is used to manage spasticity in selected children with cerebral palsy, but to our knowledge it has not been reported in children with SCI. We describe the case of a 14-year-old girl who had T2 AIS A SCI as the result of a gunshot wound at age 9 years. Within the first year of injury, she developed lower extremity spasticity and flexor spasms that significantly interfered with transfers and dressing. She sustained multiple falls with transfers, including one resulting in a tibia fracture. She was treated with oral baclofen; botulinum toxin A (BTX-A) injections to hip flexors, knee extensors, and knee flexors every 3 to 4 months; and phenol blocks to the hip adductors. The injections decreased her spasticity and spasms but the results were temporary. An intrathecal baclofen pump was recommended, but the family expressed

reservations as there were no local or regional providers who could manage and refill the pump. After an extensive discussion, she underwent a dorsal rhizotomy from L1 to S1 though a single level L2 laminectomy. After identification of the sensory nerve roots, approximately 80% of sensory roots from L2-S1 were sectioned, and almost 100% of sensory roots at L1 were sectioned. The main goals were to reduce hip flexor spasms to improve her ability to transfer and to reduce hip adduction spasticity to facilitate self-care. Preoperatively, her Ashworth Scale scores were 2 for hip flexion, adduction, and knee extension; 1+ for knee flexion; and 0 for ankle dorsi and plantar flexion. She had hip flexor spasms with every transfer. Postoperatively, she had no spasms and Ashworth Scale scores were 1+ for right knee extension and otherwise 0 throughout the lower extremities. She tapered off her baclofen and was extremely satisfied with her outcome. Dorsal rhizotomy may have a place in selected children with spasticity due to SCI.

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Validation of the Screening Tool for the Assessment of Malnutrition (STAMP) in Children with Spinal Cord Injuries (SCI)

Allison Graham

Summary: *The aim of the present study was to validate the Screening Tool for the Assessment of Malnutrition (STAMP) in paediatrics; although there are a number of paediatric nutrition screening tools (PNSTs), their use in the SCI population requires further investigation in paediatric patients with SCI. Data:* The prevalence of childhood malnutrition lies between 15% and 30% in hospital practice; it may be higher still in neuro-disabilities patients such as those with spinal cord injuries (SCIs). The aim of the present study was to validate the Screening Tool for the Assessment of Malnutrition (STAMP). A number of paediatric nutrition screening tools (PNSTs) have been developed, but their use in the SCI population requires further investigation in paediatric patients with SCI. On admission, children were screened by this tool by the nursing staff. Its validity

was assessed by (i) comparison with dietetic assessment (criterion validity); (ii) comparison with another generic PNST, the Paediatric Yorkhill Malnutrition Score (PYMS) (concurrent validity); and (iii) completion of an additional STAMP screening completed by the research dietitian to assess inter- and intrarater reliability. The levels of agreement were assessed using Cohen's κ statistics. Fifty-one children were screened. The prevalence of undernutrition risk was 42.1%. STAMP had moderate agreement with dietitian assessment (κ : 0.578, 95% CI, 0.304-0.851) and fair agreement with PYMS (κ : 0.314, 95% CI, 0.08-0.552). The STAMP had substantial reliability (interrater reliability: κ : 0.752, 95% CI, 0.568-0.935; intrarater reliability: κ : 0.635, 95% CI, 0.392-0.878). When compared with dietetic assessment, STAMP was numerically (but not significantly) less sensitive (70.6% vs 76.4%), and less specific (87.5% vs 93.7%), and it had weaker agreement than PYMS (κ : 0.58 vs 0.69). Although it is possible that the diagnostic accuracy is lower than that of other generic PNSTs, STAMP is probably still an acceptable tool for the identification of SCI children at risk of undernutrition. Further investigation is warranted to test its predictive validity.

Measurement in Pediatric SCI

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Changes in Body Composition in Spinal Cord Injury Adolescents

Claudia Lunardi

Summary: *Variables BM, BMI, SS, and WC remained stable over the 2 years, which was different than expected in adolescents with reduced mobility.*

Introduction: During childhood and adolescence, there is a gradual increase in fat mass and lean body mass, especially in subjects with low mobility due to spinal cord injury (SCI). Monitoring these variables facilitates identification of health problems associated with low levels of body fat or high levels of adiposity in this population.

Objective: To investigate changes in body mass (BM), height, body mass index (BMI), skinfold sum (SS), and waist circumference (WC) in adolescents with paraplegia due to SCI at 1 year.

Methodology: The subjects are patients of the International Network of Neurorehabilitation Sarah Lake North, Brasilia. Body composition was performed by experienced professionals, according to the following criteria: BM was measured on an electronic scale with subject in his or her wheelchair; the mass of the wheelchair was measured and subtracted from the total value. Height was measured with a stadiometer in the supine position. To measure SS, we used the following skinfolds: biceps, triceps, subscapular, pectoral, midaxillary, suprailiac, abdominal, thigh and leg, all in the right hemisphere. This was measured twice and the average was used. The subjects were evaluated once, and then they were evaluated again after 1 year. Statistical analysis was performed with general data and

gender. They were normalized and used the *t* test for paired data to compare the course of 2 years. Statistical analysis was performed using SPSS 14.0. **Results:** We evaluated 20 patients, with a mean (\pm SD) age of 14.45 (\pm 1.0), BM of 42.31 kg (\pm 5.5), height of 150.91 cm (\pm 12.7), BMI of 21.3 kg/m² (\pm 5.2), SS of 168.70 mm (\pm 89.4) and WC of 83.04 cm (\pm 16.7). There was a statistically significant increase in the variable BM for the general sample. Height also differed between years in general analysis, for males and females. No statistical difference was found in other variables with the year. **Conclusion:** These teenagers have longitudinal growth as expected for the age group. Variables of BM, BMI, SS, and WC remained stable over the 2 years, which was different than expected in adolescents with reduced mobility. These results may be due to orientation provided by rehabilitation team for encouraging practice of regular physical activity and proper nutrition.